

BBC

SCIENCE HISTORY NATURE FOR THE CURIOUS MIND

# earth

ASIA EDITION | VOL 12 ISSUE 4  
JUL/AUG 2020

INCORPORATING  
**SCIENCE  
WORLD**



**FLIGHT OF THE  
NAVIGATOR**

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## HENRY V's **GREATEST VICTORY**

AN ENGLISH MILITARY MAN'S  
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# TV HIGHLIGHTS

## The Supervet

Follow orthopedic neurosurgeon Professor Noel Fitzpatrick and his team as they provide hope, often against all the odds, for animals who are inseparable members of their families.

Premieres 3<sup>rd</sup> July  
Friday at 8:05pm (SG/HK)



## Bears About The House

In this heartwarming and at times hard-hitting series, conservationist Giles Clark helps set up a bear rescue centre in South East Asia while rearing bear cubs of his own.

Premieres 20<sup>th</sup> July  
Monday at 8:05pm (SG/HK)



## The Truth About Takeaways

How much do we know about our fast food, what is it really doing to our health, and can science help us make smarter takeaway choices?

Premieres 6<sup>th</sup> August  
Thursday at 9:55pm (SG/HK)



## Race Across The World

Five teams set off from Mexico City in a race to reach Ushuaia in Argentina.

Premieres 9<sup>th</sup> August  
Monday at 8:05pm (SG/HK)



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# WELCOME

## DISCOVERIES ANEW

Historical figures possess noteworthy tales of victory and tragedy, but their other pasts are often left in the shadows. In this edition's cover story, medieval history emeritus professor Anne Curry shines the spotlight on brilliant military man Henry V. While the former King of England's claim to fame is his soldierly triumph at the Battle of Agincourt, his diplomatic mastery in Troyes is showcased instead in Curry's riveting piece. Flip to page 70 to read Henry V's impressive ascent from English warrior to France's heir to the throne.

In the nature front, landscape lensman Ross Hoddinott narrates how he and his family moved to a quiet Cornwall farm 35 years ago and dedicated a patch of land to wildlife. He revisited his childhood spot recently and has showcased his findings on page 60 with a series of arresting images of the now-flourishing habitat. Fancy a peek into the underground world of kingfishers? Follow naturalist writer Robert E Fuller's account on stealth-watching these elusive birds and their covert life from courtship to parenthood on page 40.

There's a new wave of lab-grown bacteria in our midst, and science writer Colin Barras gets inside these research facilities to find out what they're capable of. According to him on page 30, these microbes could help clean up the planet and make it a healthier environment to live in. Another vital read in this issue is social psychologist Alex Krotoski's commentary about altering mindsets and enduring the challenges of being in quarantine a little more successfully. Her timely exposition is on page 98, and it is all sorts of relatable and helpful in the current pandemic we're all in.

Until the next issue,



Ara Luna-Reston  
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**FOR THE CURIOUS MIND**  
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## Experts in this issue



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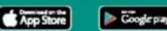
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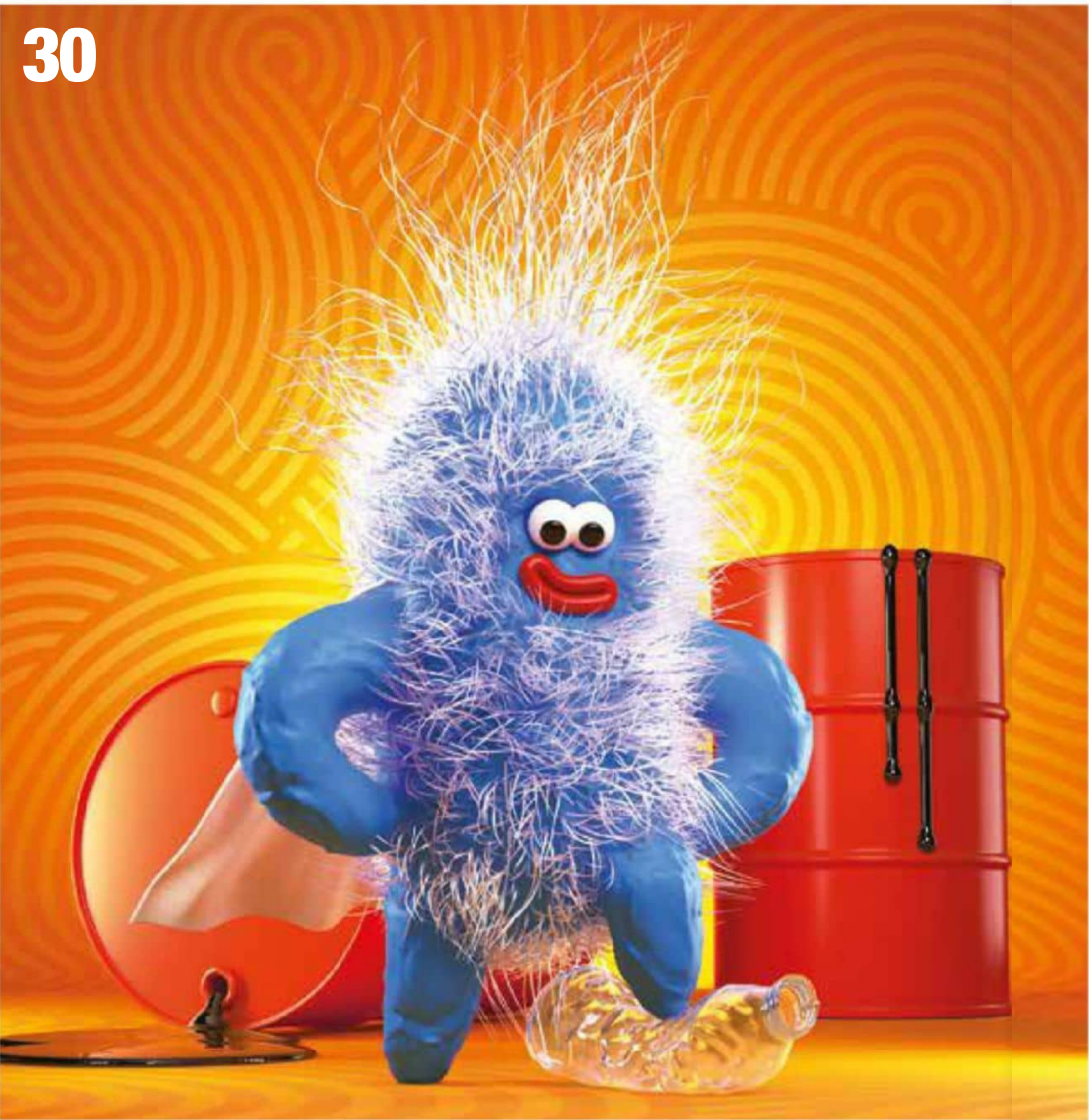
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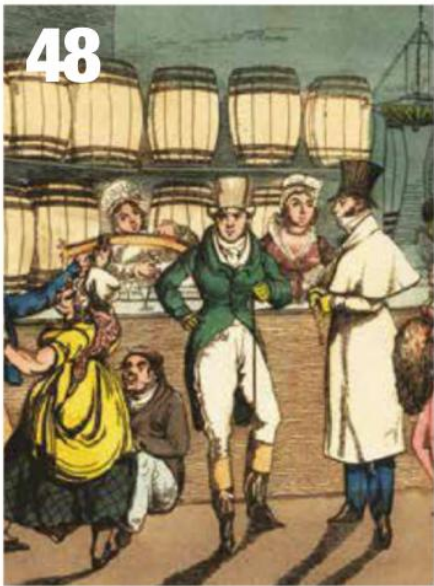
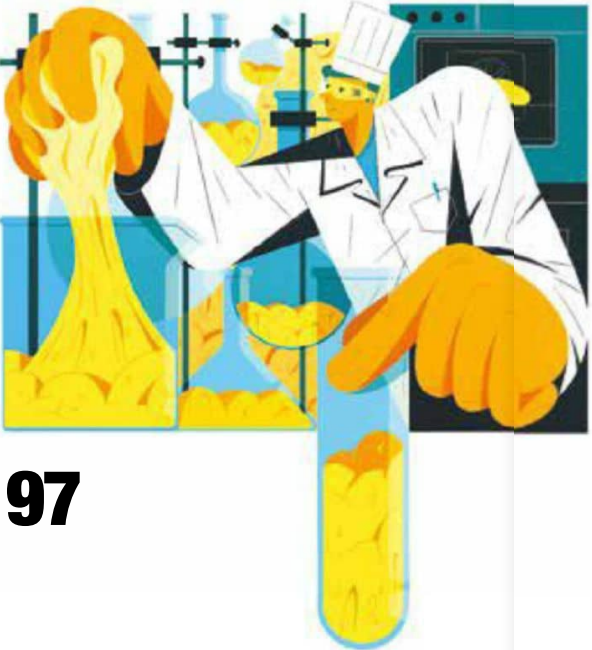
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## MEDICS ON A MISSION

FUYUN COUNTY,  
CHINA

If you didn't have access to modern technology, how would you know about the risks posed by COVID-19? Or even that a new virus had taken hold and had become a pandemic?

Travelling through rough, snowy conditions on horseback to remote parts of China's Xinjiang region in the northwest of the country, these Chinese authorities were on a mission to reach the isolated nomadic families in the Altai Mountains. Wearing face masks and hazmat suits, this was no easy journey. They travelled in February, with snow that was so deep in places that parts of the trek had to be completed on foot.

The team was comprised of police officers, medical workers, and military troops, and their aim was to carry out some basic health tests and to educate the families about prevention and treatment measures, if the virus were to reach their community.

GETTY IMAGES/BARCROFT MEDIA

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# TREE OF LIFE

PORT ANGELES,  
USA

This sitka spruce tree is just one of thousands of trees along 117,482km (73,000 miles) of coastline at the Washington Olympic National Park. For the rangers, it was of no particular significance. Until, that is, a recent outpouring of interest on social media from people all over the world, who began calling it the 'Tree of Life' or 'Tree Root Cave'.

"What makes it an enigma, I'll say, is the stream that flows out directly from underneath the tree," explains Olympic National Park lead coastal interpreter Jared Low. This is what creates the cave-like illusion. "It's not a cave; just an eroded point in the bluff. But it certainly is aesthetically mesmerising."

Most sitka spruces start from a seed that lands on a log, called a 'nurse log', Low explains. "A tree starts to grow slowly and as it gets bigger, the roots reach out, looking for nutrient-rich soil. Over time, the nurse log decomposes, leaving this wide root system."

ALAMY

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## ROBOTIC PRECISION

MUMBAI, INDIA

This rather brutal-looking machine is actually a prototype of a robot that could eventually be used for delicate neurosurgery procedures. Seen here at the National Institute of Mental Health and Neurosciences in India, it has been developed by the Bhabha Atomic Research Centre (BARC).

Instead of a model of a skull, imagine a real person securely held in place, where this robot can reach any point and from any angle. Its design makes it ideal for complex manoeuvres, and it's hoped that neurosurgeons will be able to achieve biopsies of extremely small, deep-rooted tumours. "It's capable of pinpointing where it is in relation to the brain," explains University College London computer scientist Dr Peter Bentley. "They're using MRI scans to build up a 3D model of the brain, from which they can plan the surgery. They can even do virtual surgery in a 3D simulation, before the robot does it for real."

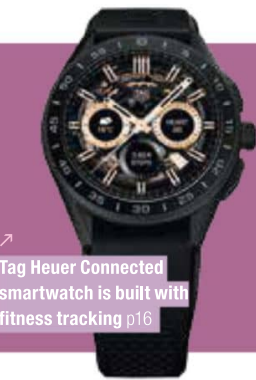
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Tag Heuer Connected smartwatch is built with fitness tracking p16

# INNOVATIONS

PREPARE YOURSELF FOR TOMORROW



The Borderlands Science mini-game is located in an arcade machine inside the world of Borderlands 3

TAKE-TWO INTERACTIVE SOFTWARE

## STEP BY STEP

### START PLAYING

Borderlands Science is housed in an arcade cabinet on Sanctuary, the ship players use to move from world to world. Jump in and be greeted with a tutorial.



### MATCH BLOCKS

Line up rows of similar colours by shifting columns of blocks. Each block symbolises a nucleotide of bacterial DNA. More matches = bigger score.



### GET REWARDS

Hit the target score in the arcade game and you will be rewarded with random loot, like guns and shields, that you can use in the game world.



## GAME ON

# GAMERS SOLVE 36 MILLION PUZZLES... FOR SCIENCE! (AND LOOT)

Borderlands players crunch through data to help scientists map the human microbiome

A team of scientists and coders set up a mini-game inside the world of Borderlands 3 back in April with the hope that the game's huge playerbase would lend their brainpower to identifying the DNA of microbes in the human microbiome – the collection of tiny organisms that live in the body and influence our health. Within a month, game developers in Gearbox have seen some 700,000 players take part in the mini-game that analyses snippets of DNA harvested from the gut via poo samples.

The players didn't need any medical knowledge (or rubber gloves) to get involved. Different building blocks of DNA, called nucleotides, from pairs of bacteria were converted into different coloured squares and arranged into columns. The players' goal was to align the coloured squares of each column with the ones next to it by moving them up and down, while introducing as few gaps (empty squares) as possible. In effect, this matching game tells scientists how similar the DNA sequence of bacteria A might be to bacteria B – if lots of blocks line up neatly in rows, then A and B share a similar ancestry and function. And if bacteria B is unidentified, but is a close relative of A, then we now understand a lot more about B.

In the game, the target score was the score achieved by an algorithm trying to carry out the same task. Gamers were challenged with toppling it to earn in-game rewards. It's the kind of task

that an AI typically struggles with because there are goals at odds with one another (maximise alignments and minimise gaps) so the gamers would typically beat the score and some would go on to set their own high score. Each outcome will help scientists who are working on the project at McGill University and the Microsetta Initiative to develop different ways to solve the problem and ultimately train an AI to do the job as well as humans can.

On its early days, the results are already promising. It seems that on average 60 per cent of the solutions were where the computer put them, and 40 per cent were positioned better, thus improving the accuracy of their identification process. Borderlands 3 players have now completed 36 million puzzles and when they hit 40 million the team will move on to bigger more complicated sequences in Phase 2.

The ultimate goal of all this puzzle-solving is to identify the bacteria living inside us and their functions. The make-up of our microbiome has been linked to many diseases and conditions, including obesity, depression, cancer, and more. If we can understand this microbial ecosystem, then we can come up with better treatments and interventions. The data is all open source so that future teams can benefit from the findings.

**"SOME 700,000 PLAYERS HAVE TAKEN PART IN THE GAME THAT ANALYSES DNA FROM GUT BACTERIA."**



ON TEST

LEXILIGHT

A READING LAMP  
DESIGNED FOR  
DYSLEXIA

Can a smart light help people to read more easily?

In the UK, around ten per cent of people have dyslexia. Dyslexia is entirely subjective to the person who suffers from it. However, for some context, I am pretty much in the middle of the spectrum. When reading, I get rivers of light running through the text, along with jumping letters and frequent skipping across words or lines. I have used coloured overlays in the past, and have glasses with coloured lenses that improve my reading experience. A small study published in 2017 in the journal Proceedings Of The Royal Society B found evidence that one cause of dyslexia could be down to a patch of light-sensitive cells in the eye. It said that in non-dyslexics, the cells are differently arranged between the two eyes, with information from one eye overriding the other. In people with dyslexia, both eyes have the same pattern. There is, therefore, no dominant eye, meaning that two pieces of information are sent to the brain at the same time, which can cause mirror images. Lexilife has launched an LED reading lamp, the Lexilight. It claims to reduce the mirroring effect by using pulsed light to allow one eye to take dominance.

Several parameters of the lamp can be adjusted, so it can be personalised to suit the user. The Lexilight is a well-made and pleasing design. It is lightweight and comes with a protective carry case to keep it safe when you're on the move. When placed on the desk, it's extremely sturdy, and you can arrange it to face the screen when you're working on a computer. Its stability is reassuring, because the adjustments needed to get the best result are precise, and much fiddling is required on the initial setup. However, once you've sorted your personal settings, you shouldn't need to do anything more than switch the light on and off as needed. Using the light for the first time is a slightly strange experience. The instructions weren't very in-depth, so I had no idea quite what to expect or what I should be aiming for with the settings. Regardless of which settings I went for, I was still seeing the rivers of light between words and, in some cases, felt the pulsing of the Lexilight was making things worse. It was when I switched off the Lexilight function and looked at the page with the normal lamp mode that I recognised the benefits of

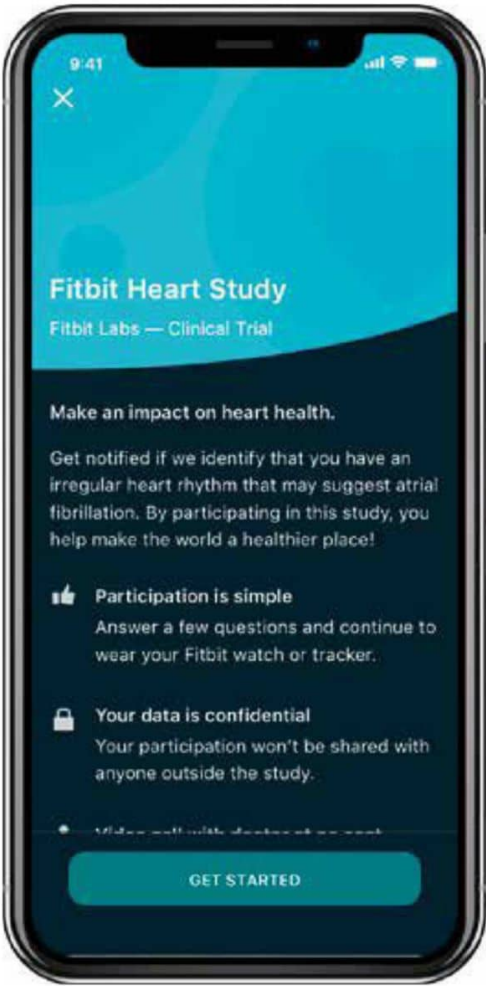
having the light switched on. When I adjusted the Lexilight to suit me, each word appeared clearer and more distinct from any words around it. It was also a lot easier to focus on the exact word I was reading, and that it helped me stay on the correct line. My rivers of light remained though, and I feel that my assumption that I would suddenly be 'cured' clouded my initial response to the light. I would add, though, that some clearer idea of the proposed benefits should be mentioned within the manual. For me, this wasn't a miracle dyslexia cure, but it was a useful addition to aid my reading. I am sure that there will be some dyslexics out there who receive even more of a benefit, particularly if they experience the mirroring effect. Plus, you can try the light for 30 days and can get a refund if you're not satisfied.

£499, [lexilife.com](http://lexilife.com)

Tom Hird (@TheBlowfish) is a broadcaster and author.



The Lexilight uses pulsed light to help people with dyslexia to read.



“MOST FITBIT  
DEVICES CAN TRACK  
YOUR HEART RATE  
24/7, THANKS  
TO IMPROVED  
SENSORS.”

Fitbit has kick-started research involving hundreds of thousands of users to find out if its heart-rate tracking tech could spot undiagnosed health conditions. The Fitbit team want to test if they can identify Atrial Fibrillation (AFib), an irregularity in the heart's rhythm that can be a precursor to stroke. Most Fitbit devices can track your heart rate 24/7, thanks to their long battery lives and improved sensors. Usually, this data charts your fitness and sleep quality, but Fitbit hopes that the long-term tracking of heart rhythm, over several days at a time, will provide a window into the wearer's heart health. To track heart rate, specific Fitbit models use a technology called photoplethysmography – a technique that detects changes in blood volume

in the tissue just beneath the skin. It works by shining a light into your skin and monitoring the light that bounces back to identify changes in blood flow, volume and oxygenation. This technology is commonly found in accident and emergency departments around the world in the shape of small clips that nurses clamp to your finger to check your oxygen levels. Participants in the experiment who receive a notification about an irregular heart rhythm will be given a virtual appointment with a doctor in the US free of charge – and could potentially receive an electrocardiogram (ECG) patch in the mail to check the diagnosis more thoroughly. Fitbit isn't the only one testing whether wearable tech can be of use in a medical setting. Apple has looked into whether it could detect AFib too, with moderate success. The tech giant has also been investigating whether its smartwatches could provide insight into other conditions, like seizures and binge-eating. Indeed, this study by Fitbit is just one piece in a broader initiative by the company to use its tech and huge customer base to develop early diagnosis tools. Fitbit partnered with Scripps Research and Stanford Medicine earlier this year to study the role that wearables could have in detecting, tracking and containing infectious diseases like COVID-19.

FITBIT INVESTIGATES  
WHETHER WEARABLES  
CAN DIAGNOSE HEART  
CONDITIONS



IDEAS WE LIKE



**VR MEETINGS**

While many of us were hopeful that working from home might spell the end of frivolous office meetings, it seems virtual conferences have replaced them via Zoom calls, Team Meetings, and Google Hangouts. Even friends and family are getting in on the action now. So why not throw some VR into the mix? If you've got two Vive VR headsets, Vive Sync lets you take your next meeting in virtual reality. It sounds cheesy, but it's useful when it comes to professions like engineering and design. You can load 3D models into the virtual space, move the object and inspect it. We attended a virtual press conference in this way last year and were pleasantly surprised at how much more immersive it was than a video conference.

HTC Vive Sync  
sync.vive.com

**PHONES WORKING THE NIGHT SHIFT**

Most modern smartphones have more processing power than my last laptop. The DreamLab app uses that computing resource at night when you're presumably asleep, and harnesses it to help scientists run simulations and computational models, just like a networked supercomputer. It's currently offering this resource to researchers looking to create vaccines and treatments for COVID-19.

Vodafone DreamLab  
Free, [vodafone.co.uk/mobile/dreamlab](http://vodafone.co.uk/mobile/dreamlab)



**A SMART-LOOKING SMARTWATCH**

Many companies follow the Apple design book when it comes to smartwatches, so it's nice to see something different. The Tag Heuer Connected is completely circular, free of protrusions or odd-shaped displays, and is fronted by a scratch-resistant sapphire crystal that protects a high-resolution OLED touchscreen. You can choose how the display looks with just a few clicks. Despite the boardroom appearance, the Tag Heuer Connected is still built with fitness tracking in mind, with GPS onboard to follow your fitness activities, including running, cycling, and golfing.

Tag Heuer Connected  
From £1,495, [tagheuer.com](http://tagheuer.com)

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| Gender                       | Age Group                      | Occupation                         | Annual Income                               |
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| <input type="radio"/> Female | <input type="radio"/> 31 - 40  | <input type="radio"/> Management   | <input type="radio"/> \$50,001 - \$100,000  |
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## HOW DID WE GET HERE? →



DEC 2019

Cases of pneumonia from an unknown cause appear in Wuhan, China.



EARLY 2020

Analysis suggests a novel coronavirus originates from a live animal market.



23 JAN

The outbreak reaches more than 500 cases across China, Japan, Thailand, and the US.



30 JAN

The World Health Organization (WHO) declares a global health emergency.



11 FEB

The new virus is given a name: SARS-CoV-2. Cases approach 50,000 globally.



14 FEB

France announces the first death in Europe, the fourth outside mainland China.



28 FEB

Cases across Europe spike with Italy at the epicentre. Global cases near 100,000.



11 MAR

With over 125,000 cases, the WHO declares COVID-19 to be a pandemic.

# PATH TO PANDEMIC

## EXPLORING THE RISE OF COVID-19

Infographic by James Round

### INFECTION RATES AND FATALITIES OVER TIME

Confirmed infections

Fatalities

22 Jan 580 cases

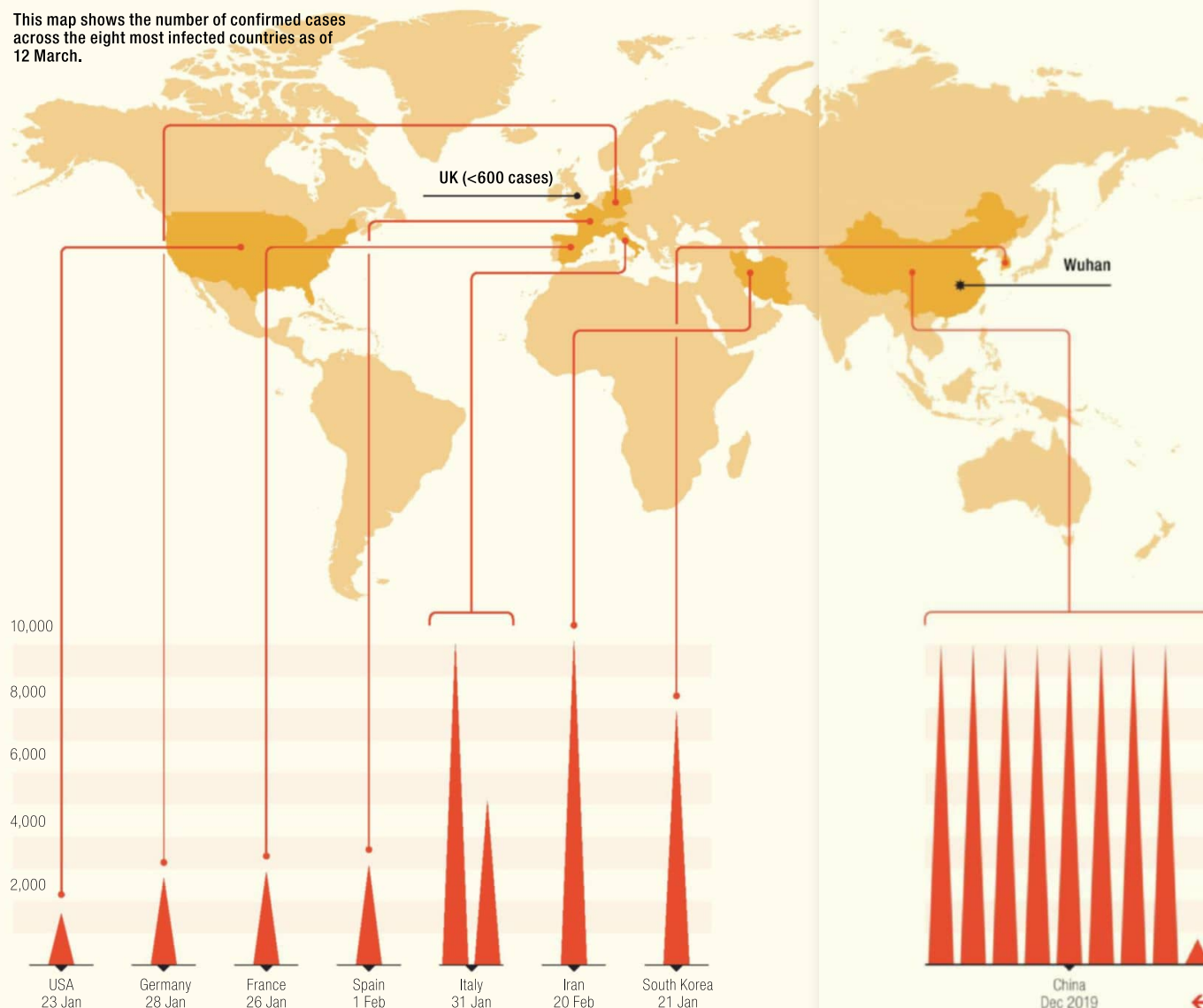
Feb &gt;14,000 cases

On 11 March, WHO declared a global pandemic &gt;125,000 cases

Mar &gt;88,000 cases

BY 12 MARCH, THERE WERE ALMOST 135,000 CONFIRMED CASES WORLDWIDE. FROM THOSE CASES, ALMOST 5,000 PEOPLE HAD DIED.

This map shows the number of confirmed cases across the eight most infected countries as of 12 March.



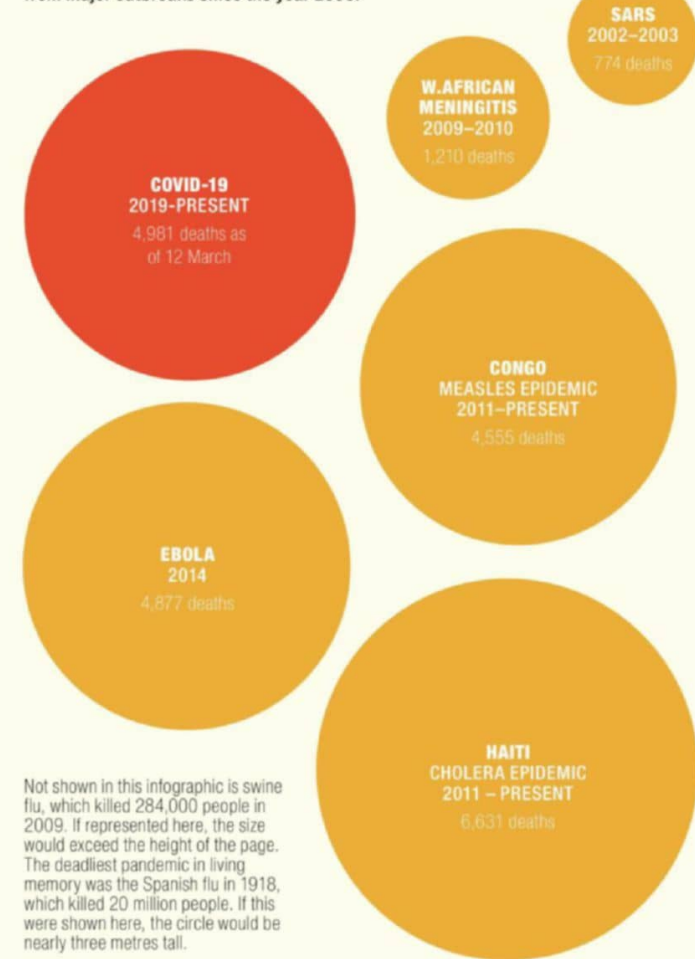
Most at risk are the elderly and those with underlying health conditions. For over 80s, there's an almost 15 per cent fatality rate.



Each country's first case

### HOW DOES COVID-19 COMPARE TO OTHER OUTBREAKS?

The circles represent the estimated number of deaths from major outbreaks since the year 2000.



Not shown in this infographic is swine flu, which killed 284,000 people in 2009. If represented here, the size would exceed the height of the page. The deadliest pandemic in living memory was the Spanish flu in 1918, which killed 20 million people. If this were shown here, the circle would be nearly three metres tall.

### HEAVILY INFECTED COUNTRIES HAVE TAKEN SERIOUS MEASURES



Recommended self-isolation



Restricted travel



Cancelled sporting and other events



Closed schools, universities, and offices

### THE GLOBAL ECONOMY IS AT RISK AS THE MARKETS DROP, BUT SALES OF SOME PRODUCTS HAVE RISEN AND CAUSED SHORTAGES



Value lost off the FTSE 100 on 12 Mar



-10%



255%



944%

Hand sanitiser

Toilet paper

### CONTROL THE SPREAD



Wash hands often with soap and water for at least 20 seconds



Use a hand sanitiser when soap and water are not available.



Cover coughs and sneezes with a tissue or your sleeve.



Put used tissues in the bin straight away, and then wash your hands.



Avoid contact with people who are unwell.



Do not touch your eyes, nose, or mouth.

### SELF-ISOLATE IF SYMPTOMS APPEAR



Stay at home. Avoid work, school, and other public places.



Ask friends or family members for help with delivery services or errands.



Avoid inviting visitors to your home.



You may need to do this for up to 14 days.

Sources: Infection and fatality data from worldometers.info. Outbreak comparison data from National Geographic.

Other sources include BBC, Business Insider, Daily Mail, World Health Organization, Our World in Data, The New York Times, The London Stock Exchange, Kantar, and Wikipedia. Data is correct as of March 2020.



A researcher tests for the presence of COVID-19 antibodies.



Electron microscope image of SARS-CoV-2 virus (purple spheres).

## CORONAVIRUS

### TEST TO DETERMINE IF YOU'VE HAD COVID-19 IS NEARLY HERE

Prime Minister Boris Johnson announced on 24 March that the government had ordered 3.5 million antibody test kits, which can identify in ten minutes whether someone has had the COVID-19 infection. The kits can be used at home, involving just a finger prick to produce a blood sample that would be tested for immune cells specific to the coronavirus.

A positive result on the test would mean that a person had successfully fought off the SARS-CoV-2 virus and would have some immunity against future infection – though for how long that immunity would last is still unknown. For some viruses, such as smallpox or polio, one instance of infection is enough to give a person lifetime immunity. Others, such as norovirus, result in immunity against re-infection for up to two years. For common colds, the body's resistance can fade after just months.

The antibody tests bought by the government won't detect a current infection, but they'll look for a type of immune cell – an

antibody – that the body creates to tackle new infections. An antibody is produced by the body as part of an immune response and is specific to fighting a particular pathogen.

Once a person with coronavirus antibodies has been identified, it is thought that their blood plasma could be used as a treatment for others infected with the virus. As soon as the antibody tests have been validated, it is likely that they will be distributed for use first by key workers, before being made available to the wider public.

“[The tests] will tell us who among individuals in our NHS and other essential workforces are immune to the virus and, therefore, safe to return to their vital work,” said David Wraith, director of the Institute of Immunology and Immunotherapy at the University of Birmingham.

Following that, the tests could be given to particularly vulnerable people, said University of East Anglia health protection professor Paul Hunter. If they were immune, they could relax the measures at which they are self-isolating. Knowing who is immune will help those people stop worrying whether or not they are putting themselves or their families at risk, Hunter said.

These tests will also be of use when a vaccine first becomes available, as it will initially be in short supply. “An antibody test would allow the vaccine to be used just for people who are not already immune,” said Hunter.

### HOW DOES AN ANTIBODY TEST WORK?

→ The antibody tests purchased by the government are known as ‘serological’, meaning they test blood serum – a component of blood plasma.

→ A blood sample is collected by pricking the end of the patient's finger using a small needle.

→ The sample is placed on a surface that contains proteins that mimic those found on the SARS-CoV-2 virus.

→ If there are COVID-19 antibodies present in the blood plasma, these bind to the proteins on the test and trigger a colour change in a small window, similar to that of a pregnancy test. This is considered a positive result.

→ No colour is a negative result, which would indicate that the person has not produced antibodies to fight the coronavirus.

→ Unfortunately, a negative result on the antibody test does not necessarily mean that the individual is not infected. If a person had recently contracted the virus, perhaps within three days before taking the test, their body might not have yet started producing antibodies at a high enough concentration to be detected by the test.

GETTY IMAGES X2, NIAD-RML, SERGEY KRASOVSKIY

### CLIMATE CHANGE IS BAD NEWS FOR NIGHTINGALES

The University of Madrid scientists have found that the average wing length of nightingales has decreased over the past 20 years. They think that later onset of spring, along with intense summer droughts, is shortening the breeding season for the birds, so they produce smaller clutches with reduced wing size.

In winter, the birds fly from breeding grounds in Europe and parts of Asia to sub-Saharan Africa. However, the team found that the shorter-winged birds were less likely to make the return trip. The shortening wings might be an example of ‘maladaptation’, where the response to a changing environment is harmful rather than helpful.



## PALAEONTOLOGY

### NEW FEATHERED RAPTOR LIVED JUST BEFORE THE ASTEROID STRIKE

A newly discovered raptor shows that these dinosaurs stalked the southwest of North America right up to the bitter end.

The raptor was discovered from a 67-million-year-old fossil, dating it to within a million years of the cataclysmic event that killed off all non-flying dinosaurs. It has been named *Dineobellator notohesperus*, which means ‘Navajo warrior from the southwest’, in honour of the people who live in the region where this dinosaur once

roamed. It belongs to a family of dinosaurs known as the dromaeosaurids, the most famous of which is *Velociraptor* – that's why these dinosaurs are commonly known as ‘raptors’. *Dineobellator* was a lightly built meat-eater, measuring about two metres in length. Features on the animal's forelimbs suggest that it boasted strong arms and claws – handy for holding onto prey, or grappling with other dinosaurs.

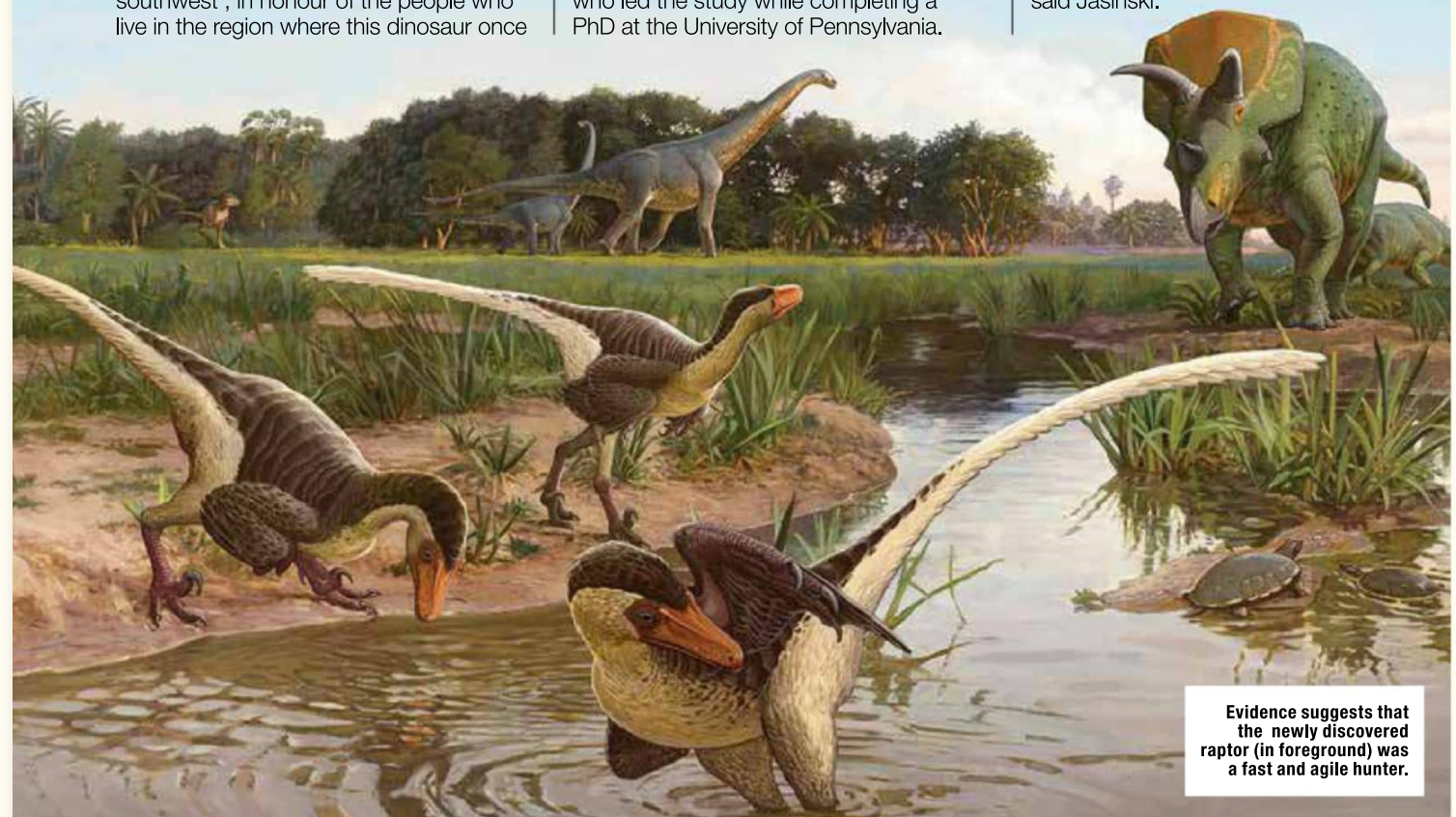
Its tail was also unusual. Unlike other raptors, it could move its stiff tail at its base, using it almost like a rudder as it raced across the ground.

“Think of what happens with a cat's tail as it is running,” said Steven Jasinski, who led the study while completing a PhD at the University of Pennsylvania.

“While the tail itself remains straight, it is also whipping around constantly as the animal is changing direction. A stiff tail that is highly mobile at its base allows for increased agility and changes in direction. It potentially aided *Dineobellator* in pursuing prey, especially in more open habitats.”

Like *Velociraptors*, it looks like *Dineobellator* sported feathers. Bones from the dinosaur's forearm had quill knobs – small bumps on the surface where ligaments would attach feathers.

“As we find evidence of more members possessing feathers, we believe it is likely that all the dromaeosaurids had feathers,” said Jasinski.



Evidence suggests that the newly discovered raptor (in foreground) was a fast and agile hunter.





A clutch of fossilised *Massospondylus carinatus* eggs found in South Africa.



## PALAEONTOLOGY

# LAB CREATES DETAILED 3D DIGITAL MODEL OF SOME OF THE OLDEST-KNOWN DINOSAUR EMBRYOS

The recreation reveals that the dinosaurs' skulls developed similarly to those of today's chickens, crocodiles, and lizards

**L**ed by the University of the Witwatersrand in South Africa, an international team of scientists built a detailed 3D model of the skulls of some of the world's oldest known dinosaur embryos. To do this, they used scanning technology powered by the particle accelerator at the European Synchrotron Radiation Facility (ESRF) in Grenoble, France.

The embryos were first found in Golden Gate Highlands National Park, Free State Province, South Africa in 1976. They belong to *Massospondylus carinatus*, a five-metre-long herbivore that lived in the region around 200 million years ago. Thanks to their small size and extremely fragile nature, the embryos are particularly difficult to study using conventional methods.

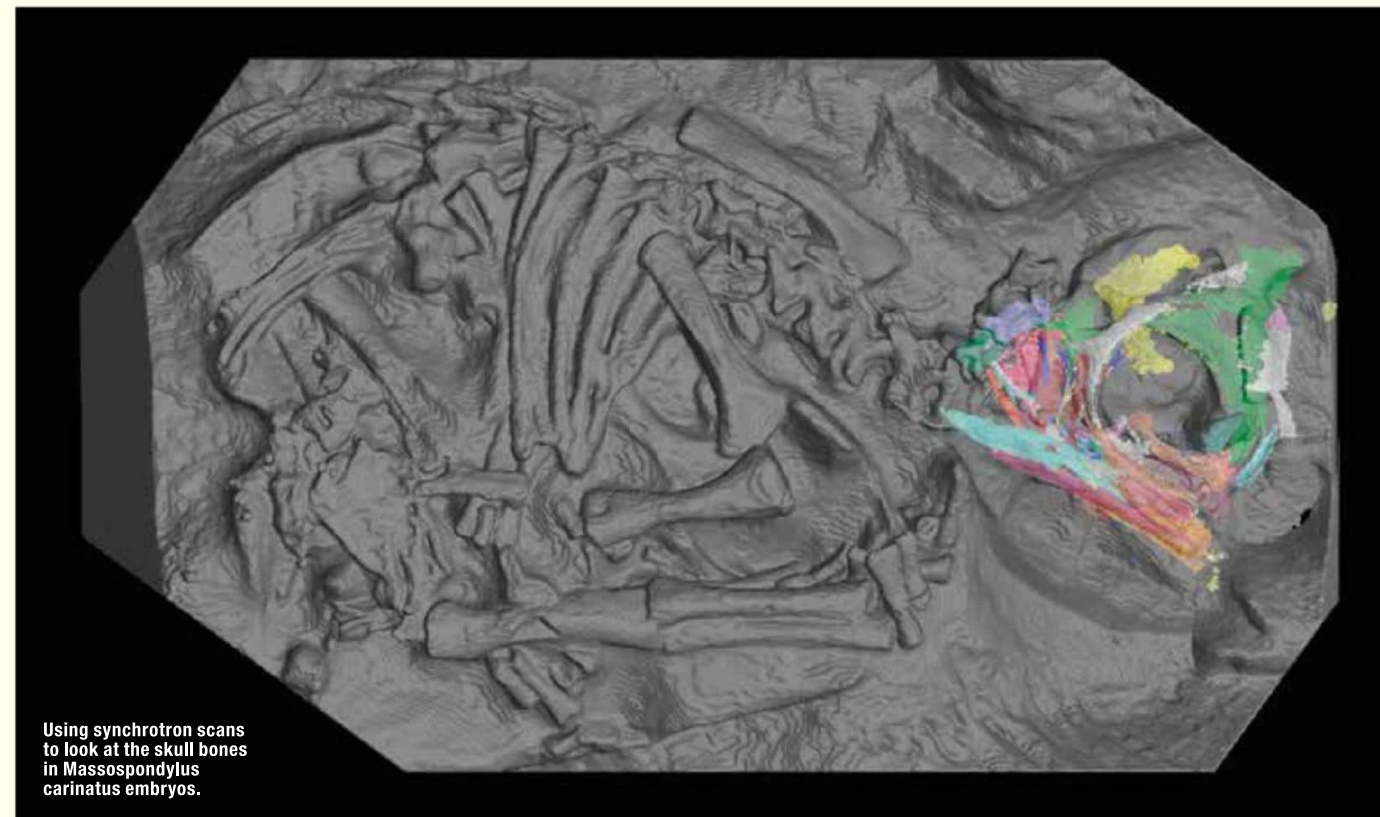
To overcome these problems, lead author Dr Kimi Chapelle and Prof Jonah Choiniere from the University of Witwatersrand took the embryos to the ESRF. The 844-metre-long circular particle accelerator can accelerate electrons to near the speed of light and produce powerful X-ray beams

## NEWS IN BRIEF

### BABIES LOVE HUGS

A study from Toho University in Tokyo, Japan, suggests that babies as young as four months old enjoy receiving a hug from their parents. The research found that when parents hugged their child, both individuals experienced reduced heart rates – as measured by an increase in heartbeat intervals on an electrocardiogram – suggesting that

they felt more relaxed. When the child was simply being held, the same calming effect was not seen. In contrast, when the infant was hugged by a female stranger, their heart rate was unaffected. According to the researchers, this offers evidence about the importance of hugging in the bonding process between young babies and their parents.



Using synchrotron scans to look at the skull bones in *Massospondylus carinatus* embryos.

that can be used to scan matter in high detail non-destructively. The scans created were so detailed that individual bone cells were visible. The dataset produced was so vast that it took the team nearly three years to process it and turn it into a detailed 3D model.

"No lab CT scanner in the world can generate these kinds of data," said Dr Vincent Fernandez, one of the co-authors and scientist at the Natural History Museum in London. "Only with a huge facility like the ESRF can we unlock the hidden potential of our most exciting fossils. The research is a great example of a global collaboration between Europe and the South African National Research Foundation."

"ONLY WITH A HUGE FACILITY LIKE THE EUROPEAN SYNCHROTRON RADIATION FACILITY CAN WE UNLOCK THE HIDDEN POTENTIAL OF OUR MOST EXCITING FOSSILS."

Upon studying the data, Chapelle noticed several similarities with the developing embryos of living dinosaur relatives – crocodiles, chickens, turtles, and lizards. The team also found that each embryo had two types of teeth

preserved in its developing jaws. One set was made up of very simple triangular teeth that would have been reabsorbed or shed before hatching, just like geckos and crocodiles do today. The second set of teeth were similar to those of adult *M. carinatus*, and would be the ones that the embryos hatched with. These data indicate that dinosaurs developed in the egg just like their reptilian relatives, whose embryonic developmental pattern hasn't changed in 200 million years.

"It's incredible that in more than 250 million years of reptile evolution, the way the skull develops in the egg remains more or less the same," said Choiniere. "It goes to show that you don't mess with a good thing!"





## TECHNOLOGY

# SHANGHAI BUSES BLASTED WITH UV LIGHT TO CONTAIN CORONAVIRUS

In Shanghai, China, a public transport company has installed powerful ultraviolet lamps in its garages to disinfect its buses. This is in an attempt to halt the spread of the coronavirus that is currently rampaging across the globe.

The cleaning process is controlled remotely and sees the buses drenched in an eerie blue light. It takes around five minutes to treat each vehicle.

Ultraviolet light is routinely used in hospitals, water treatment plants, and aeroplanes as a means of sterilisation, as it damages viruses' genetic material and prevents them from reproducing. It is known to be effective against other coronaviruses such as SARS, but it is as yet unclear whether it will have the same effect on SARS-CoV-2.

The World Health Organization warns that UV light should not be used to disinfect skin because it can cause irritation and damage to cells.



## BREASTFEEDING MAY LEAD TO FEWER VIRUSES IN INFANTS

A study at the University of Pennsylvania has found consuming even small amounts of breast milk can protect babies from a range of viruses by increasing the viral populations in their guts. The researchers measured the numbers and types of viruses

found in the first stool (meconium) and subsequent stools of newborns in both the United States and Botswana. They found that shortly after delivery, babies had little or no viral colonisation, but after just one month this shot up to as much as one billion viruses per gram of gut contents. Most of this first wave of viruses are predators that grow

in the first bacteria that colonise the infant's gut. At four months, viruses that can potentially make humans ill became more prominent in the babies' stools. The team found that breastfeeding, even when combined with formula-feeding, helped suppress the accumulation of these potentially pathogenic viruses.

## PRIMATES

# ANCIENT MONKEYS MAY HAVE VOYAGED ACROSS THE ATLANTIC OCEAN ON RAFTS

Fossilised monkey teeth unearthed deep within the Peruvian Amazon suggest that ancient monkeys journeyed there from Africa, according to a study at Keck School of Medicine, in Los Angeles.

The fossilised teeth belong to a monkey species previously unknown to science. The researchers have named the species *Ucayalipithecus perdit*, and found that it belongs to an extinct family of African primates known as parapithecids. One plausible explanation, according to the team, is that the monkeys made the trip on floating rafts of vegetation that broke off from coastlines, possibly during a storm. At the time, the landmasses of Africa and South America were closer together, which means

the voyage may have been about 1,450km (900 miles).

Based on the age of the Amazonian site and the similarity of *U. perdit* to its fossil relatives from Egypt, it is estimated that the migration might have occurred around 34 million years ago.

"We're suggesting that this group might have made it over to South America right around what we call the Eocene-Oligocene Boundary, a period between two geological epochs when the Antarctic ice sheet started to build up, and the sea level fell," said study leader Prof Erik Seiffert. "That might have played a role in making it a bit easier for these primates to get across the Atlantic Ocean."

The monkey would have been tiny, similar in size to a modern-day marmoset.

"The thing that strikes me about this study more than any other I've been involved in is just how improbable all of it is," said Seiffert. "The fact that from this remote site in the middle of nowhere, the chances of finding these pieces are minimal, plus the fact that we're revealing this very improbable journey that was made by these early monkeys. It's all quite remarkable."



*Ucayalipithecus perdit* was identified by fossilised teeth (inset). The monkey would have been about the size of a modern marmoset (main image).

GETTY IMAGES X2, ERIK SEIFFERT



### GOLF CAN HELP KEEP OLDER PEOPLE'S HEALTH ABOVE PAR

Playing golf at least once a month could lower the risk of death among adults ages 65 and older, according to the American Heart Association. Over the course of ten years, the team analysed data from nearly 5,900 male and female participants with an average age of 72. Out of the participants,

there was a lower rate of death among the golfers compared to the non-golfers (15.1 per cent versus 24.6 per cent). The researchers say that golf offers benefits like social interaction, a competitive element, and fresh air. It's also a gentle form of exercise, so people are able to continue taking part of the game as they get older.



## ENGINEERING

# A BRIDGE TOO FAR?

The UK government is apparently looking into the possibility of building a bridge between Scotland and Northern Ireland – but is this even possible?

Prime Minister Boris Johnson's official spokesperson raised a few eyebrows recently when they declared that a “proper piece of work” was being carried out looking into the possibility of linking Scotland to Northern Ireland via a bridge spanning the Irish Sea. At the moment, the leading candidates for the locations of the route are Portpatrick on the Scottish coast and Larne on the Northern Irish coast – a span of around 40km (25 miles).

Length aside, there are a number of other significant challenges that such an enormous project would raise. For example, there's the depth of the sea, which at times reaches 300 metres, and the large spans that would be required to let any ships pass under the bridge safely, explained Institution of Civil Engineers structural engineer and fellow Ian Firth.

“Another solution might be to use floating foundations; the Norwegians are doing this already,” he said. “You have a floating pontoon held below the surface of the water. You still have to get down there and drill holes in the rock down below, but you're now just tying it down with some cables. Then the buoyant platform is held below the waves – you don't want it at the surface because then you're getting wave action and tidal action. You stand your bridge structures on those buoyant platforms. That's the sort of thing that potentially could be doable.”

Even so, such a structure would still leave those travelling across it at the mercy of high winds and heavy rain, even taking into account any weather-shielding measures that could be fitted. However, there may be another solution.



“There's another type of floating structure that is a submerged, floating tunnel. It's not bored through the rock but sits under the water,” said Firth. “You tether it down, say 20 metres below the water, so that ships can go happily across the top of it, but that thing is actually floating. If you're in your car, you are driving (in effect) through a tunnel. I think this is a very interesting, and quite potentially plausible, solution.”

There are many factors to consider, such as the ability of either side of transport links crossing to cope with additional traffic. Also, the fact that it may be more efficient to upgrade the existing ferry infrastructure before any design work could begin.

“At the moment, it is an idea and not much more than that. To begin with, we'd need a pre-feasibility study which looks at what the options are so that we can actually frame the scope of a feasibility study,” said Firth. “After that, people like me could go away and agonise over what the options are. I believe it's possible. But ‘possible’ and ‘affordable’ are two different things. I'm not trying to put numbers to it, but it is eye-wateringly expensive, and nothing like it has been attempted before. But we're in the business of finding solutions to challenges. Civil structural engineers like me are good at that kind of thing.”



### NERVOUS FLYERS

Breathe easy, nervous flyers, because it's never been safer to fly on commercial airlines, a study at MIT has found. Passenger fatalities between 2008 and 2017 fell to one in nearly eight million boardings. That's down from one in 2.7 million between 1998 and 2007, and one in 1.3 million between 1988 and 1997.

### CYCLISTS

It's time to squeeze into some Lycra: cycling to work can reduce your likelihood of dying by up to 13 per cent, a study by the University of Otago in New Zealand has found.

### GOOD MONTH

### BAD MONTH

### CITY SLICKERS

Growing up in cities may negatively affect our sense of direction, data collected by the mobile game Sea Hero Quest suggests. After analysing data from almost half a million people from 38 countries, a team from the French National Centre for Scientific Research found that those who grow up in the countryside are better navigators.

### WINE LOVERS

Hotter temperatures due to climate change could make up to half of wine-producing regions unsuitable for planting grapes, a study at the University of British Columbia has found. However, switching to hardier grape varieties could lessen the impact.

GETTY IMAGES X3 ILLUSTRATIONS: JOE WALDRON



### WARNING!

Psychedelic ‘magic’ mushrooms are a Class A drug according to UK law. Anyone caught in possession of such substances will face up to seven years in prison, an unlimited fine, or both. Info and support for those affected by substance abuse problems can be found at [bit.ly/drug\\_support](https://bit.ly/drug_support).

## PSYCHOLOGY

# PSYCHEDELIC COMPOUND MAY BOOST WELLBEING OF CANCER PATIENTS

A one-time, single-dose treatment of psilocybin (a compound found in psychedelic mushrooms) combined with psychotherapy appears to help with anxiety and depression in cancer patients for up to five years, according to research at NYU Grossman School of Medicine.

In a landmark study carried out in 2016, the team found that psilocybin combined with psychotherapy sessions produced immediate, substantial and sustained improvements in anxiety and depression and led to decreases in cancer-related demoralisation and hopelessness, improved spiritual wellbeing, and increased quality of life in a group of 29 cancer patients. Six months later, they found that 60 per cent to 80 per cent of participants had significant reductions in depression or anxiety, sustained benefits in existential distress and quality of life, and improved attitudes toward death.

In a follow-up study five years later, more than 70 per cent of the participants said the psilocybin-assisted therapy brought long-term positive life changes and rated it as among the most personally meaningful and spiritually significant experiences of their lives.

“Adding to evidence dating back as early as the 1950s, our findings strongly suggest that psilocybin therapy

is a promising means of improving the emotional, psychological, and spiritual wellbeing of patients with life-threatening cancer,” said lead researcher Dr Stephen Ross. “This approach has the potential to produce a paradigm shift in the psychological and existential care of patients with cancer, especially those with a terminal illness.”

Although the exact way psilocybin works are not fully understood, the researchers believe it can make the brain more flexible and receptive to new ideas and thought patterns. Previous research indicates that it targets a network of the brain known as the default mode network, which becomes activated when we engage in self-reflection and mind wandering and helps to create our sense of self. In patients with anxiety and depression, this network becomes hyperactive, giving rise to rumination and worry. Psilocybin appears to shift activity in this network and helps people to take a more broadened perspective on their behaviours and lives.

However, the researchers warn against any attempt to self-medicate using psilocybin, noting that it should be taken in a controlled and psychologically safe setting, preferably in conjunction with counselling from trained mental health practitioners or facilitators.



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ASIAN Geographic magazine is going through a rehaul! Featuring 2020 editorial lineup

Elements of Life, Colours of Asia

In 2019, ASIAN Geographic is celebrating 20 years of bringing Asia to the world, and we have an exciting lineup ahead in 2020. Our editorial calendar will be based on a philosophical approach to Wu Xing, or the five elements in Chinese philosophy – Water, Wood, Fire, Earth, and Metal – with our last issue of the year projected to focus on bringing these elements together, all through travel.

Our first five 2020 issues will be colour-coded in blue, green, red, brown, and silver, respectively, to address our concurrent themes, and each issue will include a PASSPORT section that will focus on a specific region in Asia. The sixth and final issue of the year will be an ASIAN Geographic PASSPORT special edition that will combine all these elements and their associated colours, making the entire year’s publication come together in a stunning, rich hue – making up the perfect collection!



NO. 140 ISSUE 1/2020  
+ PASSPORT SECTION  
FEATURED REGION:  
SOUTHEAST ASIA



An inherent part of our lives, the water element is downward and inward, and its energy is stillness and conserving. This issue covers everything blue, whether by taking a plunge into the waters – where we will swim amongst issues of ocean governance, conservation, sustainability, or diving – or even just by sipping on the Asian-native butterfly pea flower tea from the pods planted in your garden.

NO. 141 ISSUE 2/2020  
+ PASSPORT SECTION  
FEATURED REGION:  
WEST ASIA



Wood, sometimes translated as Tree, symbolises growth and longevity, much like the bamboo stems that are strong, flexible, and some of the fastest growing plants in the world. As the first phase of Wu Xing, it also signifies the birth and beginning of life. This issue celebrates and navigates through the most important thing known to the living: Life itself.

NO. 142 ISSUE 3/2020  
+ PASSPORT SECTION  
FEATURED REGION:  
EAST ASIA



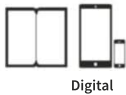
The motion of fire is upward and its energy is expansive, representing dynamism, strength, persistence, and prosperity. This issue will look at brightness, warmth, heat and the full bloom of flowers, fruits, and creativity in the arts and culture of Asia.

NO. 143 ISSUE 4/2020  
+ PASSPORT SECTION  
FEATURED REGION:  
CENTRAL ASIA



Earth is a balance of both yin and yang. Its motion is inward and centering, and its energy is stabilising and conserving. Earth is associated with practicality, hard work and stability. In this issue, we look at Asia balancing sustainability, conservation, and economic growth, as well as exciting solutions that can spur a new green economy while shining a spotlight on marine and wildlife conservation.

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A YEAR

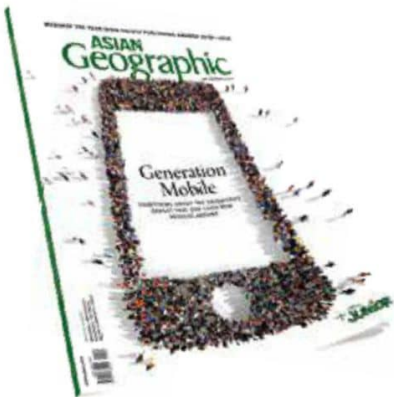
NO. 144 ISSUE 5/2020  
+ PASSPORT SECTION  
FEATURED REGION:  
SOUTH ASIA



Metal’s motion is inwards, and its energy is contracting. Metal attributes are firmness, rigidity, persistence, strength, and determination. This issue of ASIAN Geographic looks at all the special festivals and remembrance days that are celebrated by different countries and cultures all across Asia, as we contract and combine the things that make this continent so vast, yet so unique.

NO. 145 ISSUE 6/2020  
The Colour Edition:  
Passport  
TRAVEL ISSUE

This PASSPORT special edition will bring all the five elements together into a full circle, as it is meant to be, and we will explore all the corners of Asia through Wu Xing. Water, Wood, Fire, Earth, and Metal will encompass the largest continent in the world, and all the regions in Asia will be seen through this exceptional lens.



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# A NEW WAVE OF BACTERIA IS COMING SOON

WE GET INSIDE THE LABS THAT ARE GROWING BENEFICIAL BACTERIA TO GOBBLE UP POLLUTION, HARVEST WASTE, GENERATE ENERGY, AND HELP KEEP US HEALTHY

by COLIN BARRAS

**W**e're in trouble. Our over-reliance on fossil fuels and our taste for foods with a high carbon footprint is causing disruptive climate change. Our throwaway society has flooded the land and seas with plastic pollution. And we face a growing public health crisis triggered by the rise of disease-causing microbes that we cannot kill with antibiotics.

Now for the good news: the last few years have brought promising evidence that we might be able to pull carbon dioxide (CO<sub>2</sub>) out of the atmosphere and slow the pace of climate change, that we have the potential to grow high-quality protein without the large carbon footprint, and that we can clean up our pollution and blunt the impact of antibiotic resistance. The common element in all these potential breakthroughs? Bacteria. As unlikely as it might sound, our future health and happiness might be secured by these humble microbes.

## WHAT ARE BACTERIA?

Bacteria are microscopic, single-celled life forms. Bacterial cells tend to be smaller than human cells, and they have a simpler internal structure. But despite this simplicity, bacteria are astonishingly successful. They can live all over the planet in many different environments, including hot springs, hyper-salty lakes, the highest mountains, and the deepest oceans.

ILLUSTRATION MAGIC TORCH



# HUMAN HEALTH

BENEFICIAL BUGS THAT HEAL THE BODY.

**B**acteria can be terrible for human health. They could trigger deadly diseases, including tuberculosis and cholera. As a consequence, bacteria-killing antibiotics have been called one of the greatest discoveries of the 20th Century: penicillin alone has saved an estimated 200 million lives over the last 80 years.

But bacteria can also be great for human health. Recently, we've learned that each of us carries trillions of beneficial bacteria and other microbes on our skin and inside our guts. Not only can they help us extract energy from our food, these 'good' bacteria sometimes protect us from disease-causing 'bad' bacteria. This is because the bad bugs can't colonise our guts if the good bacteria take up all of the available space.

Or they do unless we disturb them. A downside of taking a prolonged course of antibiotics is that the drugs can kill off some of the good bacteria in our gut, offering disease-causing microbes like *Clostridioides difficile* an opportunity to take up residence there. *C. difficile* infections can cause diarrhoea, nausea, and fever.

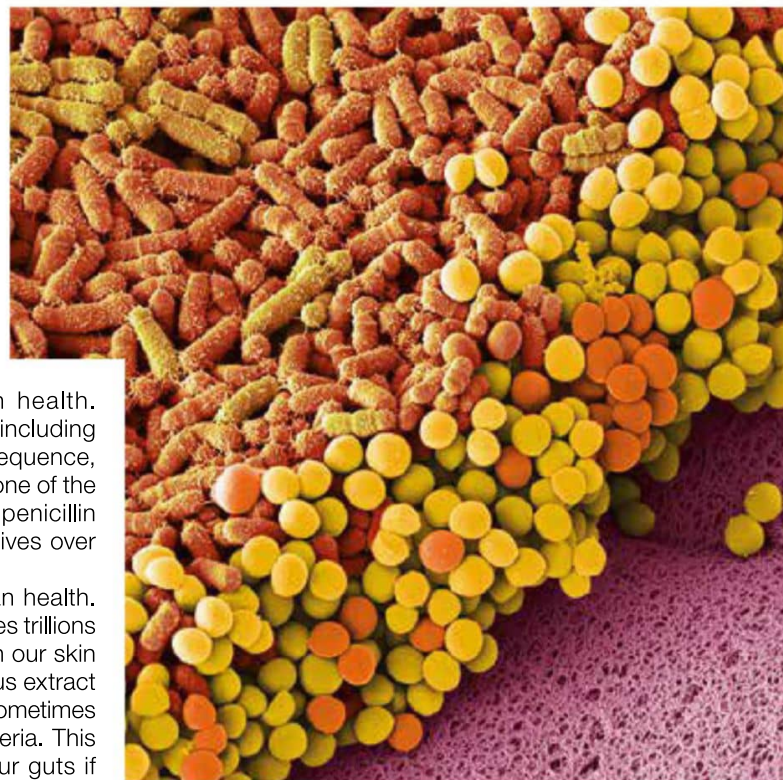
However, studies over the past couple of decades have highlighted a surprising way to treat *C. difficile* infections. If a sample of poo from a healthy volunteer is transferred into the diseased gut, the good bacteria it contains can outcompete the *C. difficile* growing there.

These 'faecal transplants' can help treat other diseases, too. But for the moment it isn't clear exactly how. Vanderbilt University professor Seth Bordenstein in Tennessee studies the interactions between animals, microbes, and viruses. In his study, he points out that we don't know exactly which bacteria in the poo samples are responsible for the health benefits.

**"SOME STRAINS OF *E. COLI* CAN SEEK OUT AND GROW**

**INSIDE TUMOURS, MAKING THEM A SUITABLE VEHICLE TO**

**DELIVER CANCER THERAPEUTICS."**



Scanning electron microscope image of bacteria cultured from human faeces.

At the opposite end of the spectrum, there are bacteria we could use in medicine precisely because we know how they work. This is particularly true of *Escherichia coli*, a mostly harmless species that is at home in the human body. Researchers have learned so much about *E. coli* through the decades that it is now essentially a tiny, programmable bio-computer that could be used to treat disease.

"Some probiotic [health-benefitting] strains of *E. coli* can seek out and grow [inside cancer tumours], making them a suitable vehicle to deliver cancer therapeutics," says PhD student Candice Gurbatri at Columbia University in New York.

Gurbatri is working with Professor Tal Danino, also at Columbia University, to harness this tumour-seeking behaviour. They have inserted extra DNA into *E. coli* that allows the bacteria to manufacture potent cancer-fighting molecules called 'nanobodies'. Another snippet of extra DNA encourages *E. coli* cells to self-destruct once they have multiplied within the tumour, showering the cancerous tissue with the nanobodies. The end result is a form of *E. coli* that, when swallowed, will target and help destroy tumours.

Earlier this year, Gurbatri, Danino, and their colleagues tested the approach in mice with promising results. But there will be regulatory hurdles to clear before human trials can begin. There are, understandably, ethical and safety concerns around the idea of treating people with genetically engineered microbes.

# RENEWABLE ENERGY

THE PROMISE OF BACTERIAL BIOFUELS.

**B**acteria are extraordinary chemists. Not only can they manufacture powerful anti-cancer drugs, but they can also churn out renewable biofuels.

Earlier this year, University of Manchester professor Nigel Scrutton and his colleagues published a study showcasing this potential. They modified an enzyme called 'fibroblast activation protein' (FAP) that's found in many bacteria so that it breaks down human food waste through fermentation and generates propane gas. Propane is used in transportation fuel and domestic heating and cooking.

This on its own is a promising starting point for a commercially viable system. But Scrutton and his colleagues have boosted their chances of industrial success by inserting their enzyme into *Halomonas* bacteria, one of the few microbes able to survive in unusually salty water. Most industrial fermentation systems are built from steel that must be carefully sterilised to make sure no rogue microbes enter the fermenter and reduce its efficiency. But as a *Halomonas* fermentation system uses salty water to operate, it saves on the need for this costly sterilisation because essentially nothing but *Halomonas* can survive.

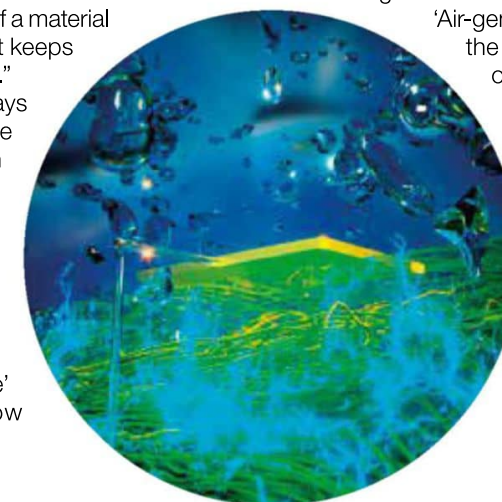
"You could perform this fermentation even in a cheap reactor made out of a material like plastic," says Scrutton. "It keeps the capital investment down."

There are several other ways in which bacteria can generate biofuels. One approach involves some unusual species of bacteria that eat and excrete electrons (negatively-charged subatomic particles), generating electricity. Stick an electrode in the ground in the right environment, and a colony of these 'electroactive' bacteria will begin to grow around it.

University of Massachusetts professor Derek Lovley and his colleagues have spent several years working out how to use these microbes for renewable energy generation. In 2010, they took *Sporomusa ovata* bacteria and gradually starved them of their preferred 'food' – hydrogen – while also providing them with ample electricity. Eventually, the microbes adapted to feed on the electrons instead of the hydrogen, and then used the electrical energy to convert CO<sub>2</sub> into acetate. This commercially attractive salt can be turned into biofuels or plastics. Lovley calls the process 'microbial electrosynthesis', and it carries the potential to generate biofuels more efficiently than agriculture can. This is because the electricity to microbial power synthesis can come from solar panels, which are – perhaps surprisingly – a more effective way to capture solar energy than the photosynthetic plants, like rapeseed, currently used to make biofuels.

Earlier this year, Lovley and his colleagues revealed yet another way bacteria could help us produce sustainable energy. Some electroactive bacteria grow tiny electrically-conductive hairs: the researchers plucked off those hairs, sandwiched them between two electrically-conductive gold plates – and discovered the device generates electricity spontaneously. Their 'Air-gen' device pulls power directly from the air, apparently taking advantage of differences in humidity to do so.

Lovley and his team calculated that they could scale up Air-gen devices to outperform today's commercial solar panels – and unlike solar panels, Air-gen would work at night, too.



Artist's impression of the 'Air-gen' device that generates electricity from thin air.

GETTY IMAGES, YAO/LOVLEY LABS/UNIVERSITY OF MASSACHUSETTS AMHERST





**“ELECTROACTIVE’ MICROBES INCLUDING GEOBACTER  
AND SHEWANELLA CONSUME WASTE IN THE WATER AND  
EXCRETE ELECTRONS.”**

**B**acteria are the ultimate recyclers. While humans have traditionally looked on sewage as a waste product, bacteria have always treated it as food. This is why bacteria play a crucial role in wastewater treatment plants. However, running those plants can be expensive: we usually rely on oxygen-consuming microbes to break down the waste, which means wastewater must be kept aerated with air pumps that are costly to operate.

It doesn't have to be that way, says Cambrian Innovation in Massachusetts co-founder and CEO Matthew Silver. Cambrian has developed an approach for cleaning industrial wastewater that generates more energy than it consumes. This is possible, says Silver, because industrial wastewater is often full of energy. Wastewater from the dairy industry, for example, can be rich in carbohydrates and proteins. “What we're treating – the complex carbohydrates – is basically like a fuel,” he says.

The company's system largely relies on bacteria that can grow in the absence of oxygen, which saves the cost of running air pumps. In one part of the system, ‘electroactive’ microbes including *Geobacter* and *Shewanella* consume the waste in the water and excrete electrons and other charged particles. Elsewhere in the system, so-called ‘methanogenic’ bacteria use some of these particles as a source of energy to convert CO<sub>2</sub> into methane gas. “The methane can then be burned to generate heat or electricity,” says Silver.

The idea of using microbes to treat wastewater and generate power simultaneously goes back more than 15 years, but going from lab-based demonstrations to a commercially viable system has proved difficult. “The energy density in sewage is low, so the volume you need to process to provide much power is enormous,” says Cornell University professor Buz Barstow in New York, who researches the potential for bacterial energy generation.

But Silver says the economics become more attractive when the technology is used at industrial sites because industrial wastewater typically contains a higher volume of energy than municipal sewage.

# WATER PURIFICATION

BACTERIA THAT FEED ON DIRTY WATER.

Water-treatment plants rely on microbes to break down waste

# FOOD

PROTEIN FROM THIN AIR?

**B**acteria could feed the world. While some bacteria turn CO<sub>2</sub> into valuable fuels, other bacteria – called ‘hydrogenotrophs’ – can transform CO<sub>2</sub> into proteins suitable for human consumption.

In a sense, this shouldn't come as a great surprise. The plants we eat, or that we feed to livestock, grow because they take energy from the Sun and use it to convert CO<sub>2</sub> into carbohydrates. Strictly speaking, plants didn't evolve this ability to transform CO<sub>2</sub> into food: they gained the skill by incorporating photosynthetic bacteria into their cells.

Solar panels are more effective than photosynthetic organisms at capturing solar energy, and this raises an intriguing possibility. If we can take solar electricity and use it to help bacteria build protein from CO<sub>2</sub>, we could grow food more efficiently than ever before.

Solar Foods, a Finnish start-up, is one of several companies aiming to commercialise this non-photosynthetic food. Dr Pasi Vainikka, the company's CEO, says the approach involves using power from solar

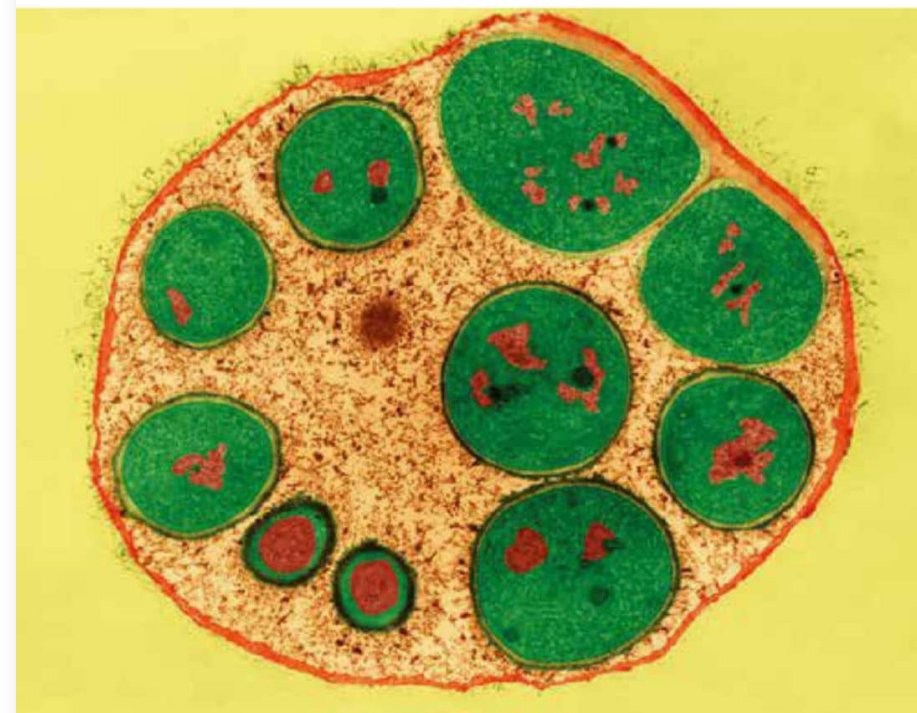
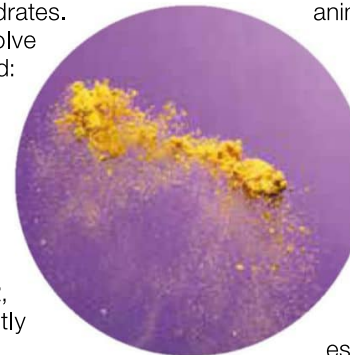
panels to break down water molecules and generate hydrogen gas. Solar Foods then feeds the hydrogen to bacteria growing in a fermenter – for commercial reasons Vainikka prefers not to reveal exactly what species of hydrogenotroph this is. The microbes use this hydrogen as an energy source to turn atmospheric CO<sub>2</sub> into a high-quality protein that could replace animal proteins in our diet.

“We are disconnecting food production from agriculture,” says Vainikka. Doing so has advantages. For instance, the fermenters that Solar Foods will be using in the coming years don't take up much room. “We are basically operating a brewery,” he says. Even allowing for the fact that the fermenters must be hooked up to solar power plants, the total land requirements are still small: Vainikka estimates that Solar Foods could produce a given amount of protein on one-twentieth of the land that a traditional farm requires.

This has the potential to allow some farmland to be converted to forest, which soaks up more CO<sub>2</sub> than cropland does. “On a systemic level, we could be carbon negative,” says Vainikka.

Cornell University professor Buz Barstow in New York says that research suggests there's a tremendous amount of potential for the creation of planet-friendly protein using bacteria and other microbes.

Vainikka envisions the Solar Food product as an additive to boost the protein content of foods like bread and pasta, or plant-based drinks such as oat milk. And although the company – and others like it – may sink or swim on consumer attitudes, there are reasons to be optimistic that consumers may be willing to eat bacterial protein. After all, the UK-based manufacturer Quorn has sold microbially-generated protein for years – although it is made by fungi, not bacteria.



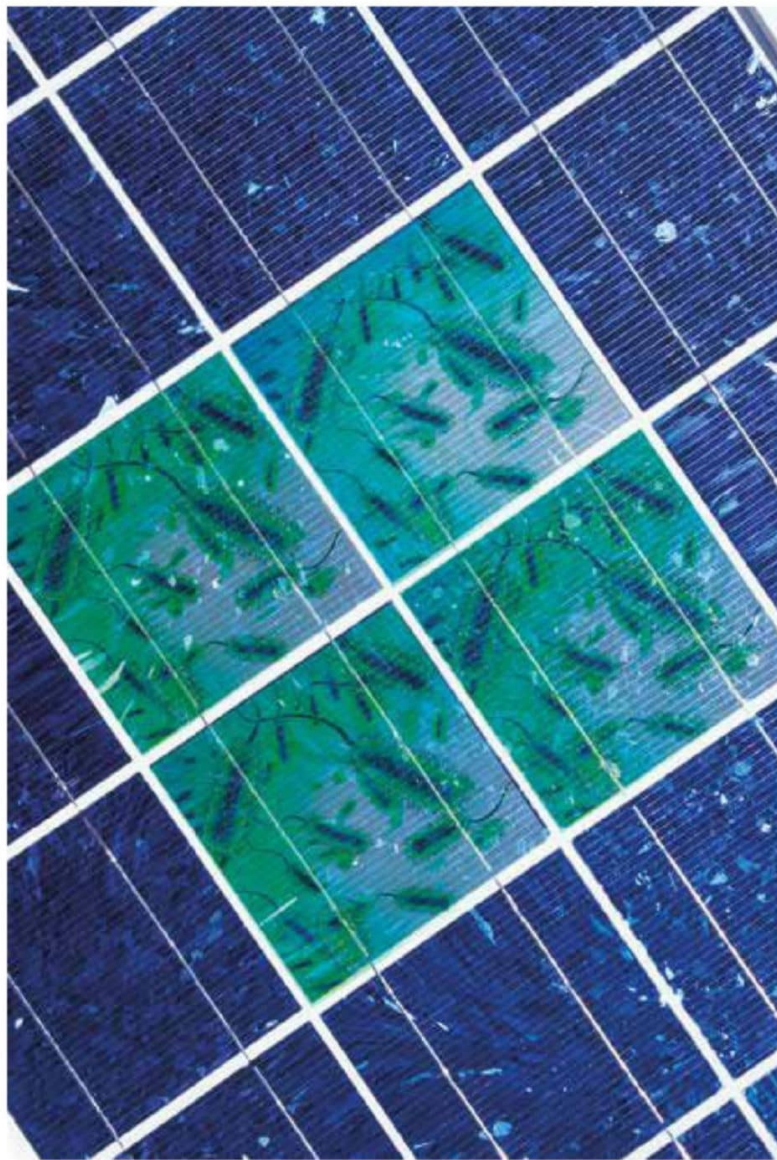
Photosynthetic bacteria can use energy from the Sun to transform CO<sub>2</sub> into food.

GETTY IMAGES, SCIENCE PHOTO LIBRARY, SOLAR FOODS



# CLIMATE CHANGE

GOBBLING UP GREENHOUSE GASES.



**B**acteria may be tiny, but they could have a huge impact on the battle to limit climate change. This is because many species of bacteria will 'eat' CO<sub>2</sub>, our principal greenhouse gas. But there is a flaw in this idea: bacteria only munch through CO<sub>2</sub> slowly.

Faster-growing microbe species could remove more CO<sub>2</sub>, but those bacteria prefer to eat sugar over CO<sub>2</sub>. Last year, however, Weizmann Institute of Science professor Ron Milo and his colleagues in Israel showed that it was possible to turn a fast-growing microbe – *E. coli* – into a CO<sub>2</sub> consumer.

Milo's team modified *E. coli* by inserting DNA from CO<sub>2</sub>-consuming photosynthetic bacteria. Then they put the *E. coli* in an environment with high concentrations of CO<sub>2</sub> and almost no sugar. After about a year, the *E. coli* had evolved to feed off the CO<sub>2</sub>.

"Our work provides a proof-of-concept that dramatic changes in the metabolism of commonly-used microbes are attainable within reasonable time scales," says team member Dr Schmuël Gleizer, also at the Weizmann Institute. The *E. coli* gains the power it needs to eat CO<sub>2</sub> from formate, a chemical that can be generated using renewable energy from solar panels. In theory, says Gleizer, a solar panel-*E. coli* system could be ten times more efficient than photosynthesis at removing CO<sub>2</sub> from the atmosphere.

"I honestly think it's a major breakthrough," says University of Greifswald professor and biotechnologist Uwe Bornscheuerm in Germany, who was not involved in the study. As the research develops, it could have a significant positive impact on global warming, he adds.

Other scientists are experimenting with 'probiotics for soil' by injecting the dirt beneath our feet with carefully-selected microbes that both boost the soil's carbon-storage capacity and accelerate the growth rate of crops planted within it. Some researchers claim that, after the application of soil probiotics, a hectare of farmland can store an additional ten tonnes of CO<sub>2</sub>. This implies, they say, that the world's agricultural land has the potential to absorb all of the carbon that humanity emits in one year.

But such research is controversial. The problem, according to University of Southern Queensland ecologist Dr Adam Frew in Australia, is that we don't know enough about the nature of the microbial communities in soil, which makes modifying them in a beneficial way difficult. "There are no simple shortcuts," he says. Microbes may have the power to improve the carbon-storage potential of soil, but a better approach might be to achieve this by nourishing the bacteria already living in the dirt rather than adding new ones.

**A system that combines solar panels with *E. coli* bacteria could efficiently remove CO<sub>2</sub> from the atmosphere.**



**After the Deepwater Horizon oil spill, pollution-munching bacteria were found in oil slicks, like the one below.**

# POLLUTION

CLEANING UP CONTAMINATION.

**B**acteria will eat almost anything that contains carbon. Some microbes have even adapted to munch through oil spills and other forms of pollution. "There were big blooms of bacteria around the Deepwater Horizon oil spill [in the Gulf of Mexico in 2010]," says Washington University professor and microbiologist Gautam Dantas in St Louis, Missouri.

This oil-eating ability has not gone unnoticed: researchers around the world are analysing the bacterial communities in soils near oil spills to identify which species are best at degrading the pollutant. The idea is that blends of these oil-eating microbes could be injected into the dirt anywhere in the world where oil pollution is a significant issue.

A potential problem with this approach is that, as with the soil probiotics for crops, we don't know a lot about the microbial communities within the soil. "Microbes added to the soil will probably struggle to compete against the indigenous microbes already there," says Dr Hermann Heipieper at the Helmholtz Centre for Environmental Research, Germany.

But bacteria are still an essential component in clean-up operations. The broader point to bear in mind is that microbes have a fantastic capacity to evolve and adapt to consume new foods. If the soil around an industrial plant becomes contaminated with oil, the chances are that some of the microbes in that soil will begin eating it. We can help them consume their meal more rapidly by providing them with the other nutrients they need to remain healthy – an approach called 'biostimulation'. "This is regularly done by adding nitrogen, phosphorus, and iron fertilisers," says Heipieper.

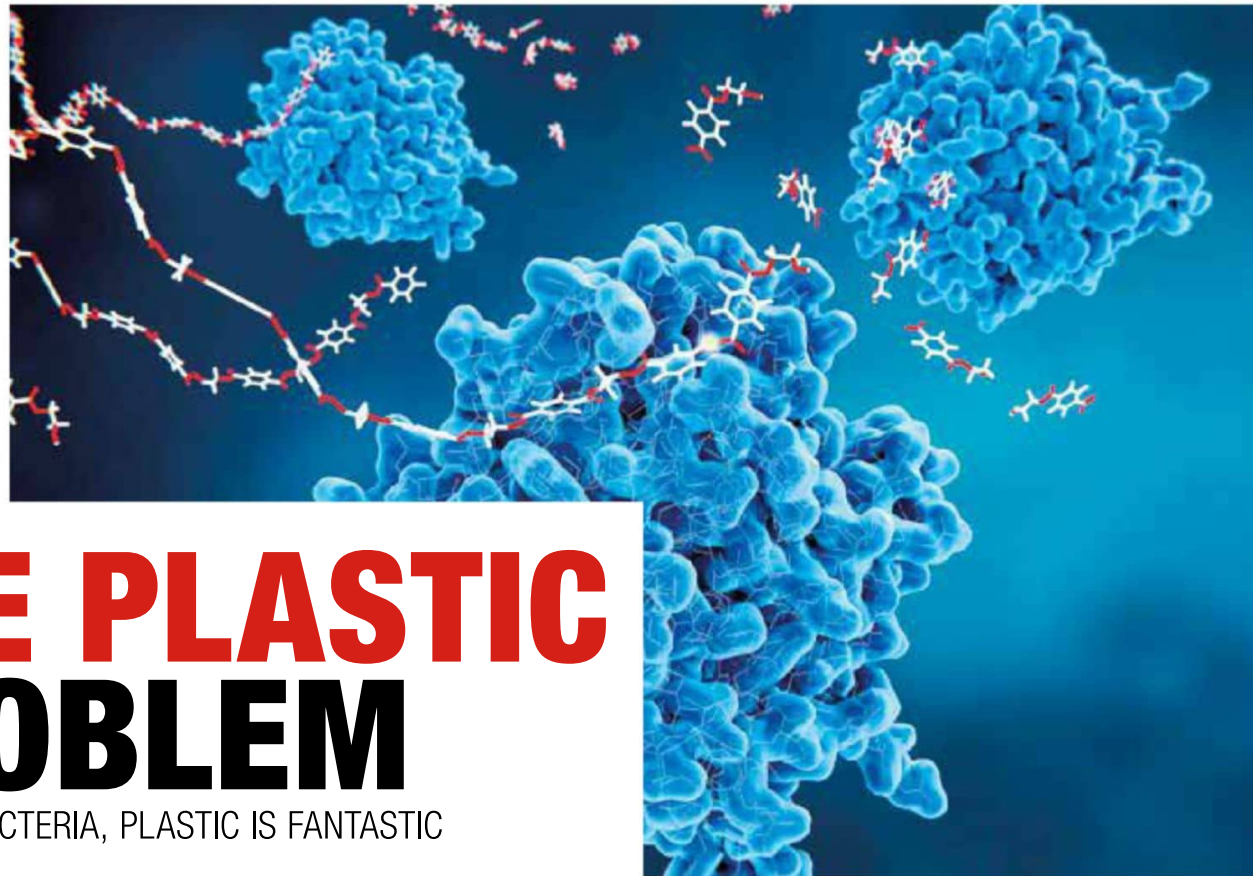
It's also possible to genetically engineer bacteria so that they convert heavy metals, such as mercury, into less toxic forms – but there are ethical and safety concerns about releasing genetically modified organisms into nature.



Illustration of PETase enzymes (blue) breaking down PET plastic (red and white).

# THE PLASTIC PROBLEM

FOR SOME BACTERIA, PLASTIC IS FANTASTIC



**B**acteria are not fussy. Like oil, they'll eat the refined, carbon-containing products that we manufacture from that oil. Like plastic, for example.

In 2016, a team in Japan went to a recycling site and collected samples of the plastic 'polyethylene terephthalate' (PET), which is used to make drinks bottles and the polyester in our clothes. They discovered that, on some of the samples, there were plastic-eating bacteria. The microbes were using a pair of enzymes, dubbed 'PETase' and 'MHETase', to break down the plastic into smaller molecules such as ethylene glycol, which can be recycled to make new plastic. The researchers named the bacteria *Ideonella sakaiensis*.

What makes the discovery all the more astonishing is that PET plastic has been polluting the natural world for no more than 80 years. "It's not long for this bacterium to have evolved [to eat] this novel, man-made carbon source," says Prof Uwe Bornscheuer at the University of Greifswald, Germany.

*I. sakaiensis* eats plastic in the environment slowly, but biologists can help by isolating the plastic-eating enzymes inside the bacteria and tweaking their structure to make them work more efficiently. In 2018, a team led by University of Portsmouth professor John McGeehan engineered a version of the *I. sakaiensis* PETase enzyme that was almost 20 per cent more efficient at breaking down plastic. They are now trying

to discover and engineer other bacterial enzymes that work efficiently enough for commercial use on a range of polluting plastics.

A study published earlier this year suggests success is possible. Researchers at French company Carbios took a bacterial plastic-eating enzyme – LCC – that was isolated from a compost heap about a decade ago and tweaked its structure in the lab. Normally, the enzyme breaks down PET plastic over several days: the engineered version could do so in a matter of hours. The researchers then used the enzyme to break down waste PET plastic and turned the building blocks they produced into plastic bottles that were identical to 'virgin' bottles created from oil. "This is a great proof-of-principle that enzymes can be engineered to help recycle some of our most polluting plastics," says McGeehan, who was not involved in this study.

It's not just PET plastic that bacteria will eat. Earlier this year, Dr Hermann Heipieper and his team at the Helmholtz Centre for Environmental Research, Germany, found evidence that some bacteria may be able to break down polyurethane, used to make insulation and car parts. "Reports are coming in from all over the world of bacteria that can degrade plastics – it's really exciting," says McGeehan.

# ANTIBIOTICS

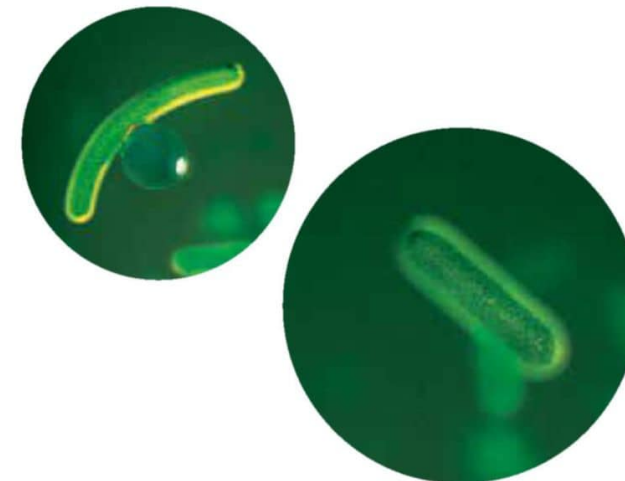
CAN BACTERIA HELP UNDO THE DAMAGE THEY CREATED?



"WE'VE FLOODED THE ENVIRONMENT WITH ANTIBIOTICS,

WHICH HAS GIVEN BACTERIA THE OPPORTUNITY TO

EVOLVE RESISTANCE."



**I**t was only in 1928 that Alexander Fleming discovered penicillin, the first antibiotic, and it was such an important finding that we still rely on these bacteria-slaying drugs to stay healthy. But by using (and overusing) antibiotics, we've flooded the environment with them, which has given bacteria ample opportunity to evolve resistance to many of the drugs. Surprisingly, though, bacteria might be able to help us with the very problem they created, because some of them eat antibiotics.

"I've been working on this for a dozen years, but it's still surprising to me that it happens," says Washington University professor Gautam Dantas in St Louis, Missouri.

In 2018, Dantas and his colleagues worked out which enzymes help some soil bacteria to eat penicillin. They then transferred the ability into the super-common, mostly harmless, microbe *E. coli*. It's possible that such modified bacteria could eventually be used in wastewater treatment plants to remove antibiotics from the water – although Dantas points out there are significant hurdles to clear before that could happen. Perhaps the greatest problem is that microbes swap DNA with other microbes they meet, so there would be real concerns that antibiotic-eating genes would pass into other bacteria, and ultimately into species that cause dangerous diseases. In that case, the harmful bacteria would have the ability to eat the drugs that are being used to fight them.

But given enough time to work with the bacteria, researchers may well find ways to overcome such obstacles and turn bacteria into a key weapon against antibiotic resistance. The idea won't surprise anyone aware of the astonishing potential bacteria have to overcome the many challenges we present them with – from destroying CO<sub>2</sub>, plastic and pollution, to creating food, clean water, renewable power, and targeted cancer treatments. **SA**

Illustration of antibiotics (spheres) killing bacteria (rods).

Colin Barras is a freelance science writer and editor based near Ann Arbor, Michigan.

ALAMY, SCIENCE PHOTO LIBRARY



# OUT OF SIGHT

PLYWOOD, BALLOONS, AND INGENUITY ARE REQUIRED IF YOU WANT TO CREATE A HIDE THAT WILL REVEAL THE UNDERGROUND WORLD OF KINGFISHERS

Words and Photos by  
**ROBERT E FULLER**



SCAN THIS QR CODE  
FOR THE AUDIO READER

You may be used to seeing kingfishers in the light of day, but these brightly coloured birds raise their young in dark subterranean nest chambers.





It's mid-January and I'm wading thigh-high through a stream, looking for kingfishers. Minnows dart before each footstep. I hear a faint, high-pitched peeping sound ahead and slow my pace. A flash of orange and cobalt blue whizzes by.

As an artist, I find the vivid pallet of kingfishers irresistible, and I have painted them often. Over the years, I've learned a lot about their behaviour, but I've always longed to discover what happens when these bright birds disappear underground to bring up their young in the dark.

I follow the sound, looking for a steep bank where this kingfisher might make its nest. But I find nowhere suitable and so head instead to some nearby flooded gravel pits owned by a friend. She tells me the bank where kingfishers regularly nest has collapsed, and so I offer to restore it in exchange for setting up a hide to photograph them.

And so begins an ambitious project to turn a shed into an artificial riverbank. I partition the space into three – to accommodate an artificial kingfisher nesting chamber, a CCTV camera system, and room for me to sit and watch the action. I coat the shed in a mix of cement, earth, and tree roots to make it look as natural as possible and, with the help of two friends, place it in the site over four freezing-cold February days.

On the final day, as night draws in, I glimpse a silhouetted form-skimming over

the water. It lands briefly next to the bank then flies off – I'm almost certain it's a kingfisher. When I return a few weeks later, I discover the tunnel is worn smooth. White droppings are splattered like paint across the nest chamber, and on the soil floor lays a peanut-sized cream pellet. I crumble it between my fingertips to reveal fine fish bones and tiny translucent scales, evidence that kingfishers are using this nest. Silently, joyfully, I punch the air.

#### CAPTIVATING COURTSHIP

Photographing kingfishers on the nest is a delicate operation – one false move and they can bolt. To avoid disturbance, I set my CCTV cameras rolling and leave the site for several weeks, only visiting after dark to furtively scan through the footage of the early stages of nesting. Mostly, I see the female coughing up then carefully shredding a pellet over the nest floor. Over time, she is able to fashion a scape in it.

I've not captured any footage of the pair together, but this doesn't surprise me. Kingfishers are essentially solitary birds and have to overcome a natural aversion to one another to breed. I observe an awkward undertone to their courtship, which starts with the pair chasing each other. Each time, their noisy and frantic game ends near my artificial bank, which I take as a good sign.

## HOW TO SEE KINGFISHERS

- Kingfishers live along clean waterways, so start your search there. You are most likely to see them in spring and summer – they are particularly active in the early morning. Use your ears as well as your eyes – you'll often hear the piercing 'peep-peep' of a kingfisher before you see it.

- These birds will habitually return to favourite perches to fish from, so scan any protruding twigs and branches that hang over the water.

- Be patient. Anglers often see kingfishers because they sit quietly by riverbanks for long periods. But don't get too close to these birds – kingfishers are a Schedule 1 species, and it is illegal to disturb them at their nest site without a special licence from Natural England.



**SOLITARY KINGFISHERS HAVE TO OVERCOME A NATURAL**

**AVERSION TO ONE ANOTHER IN ORDER TO BREED.**

Next, the male puts on a spectacular aerial display above the bank. He flies high in the sky, lapping the lakes below in ascending circles and peeping excitedly. Then, quite suddenly, he turns and plummets towards the female.

She rocks her head back and responds with a crescendo of high-pitched staccato peeps. He whizzes past, flying so close that the feathers on her head flatten in the slipstream. She loses her balance and flutters her wings to regain her poise. The male, clearly out of breath, lands near the nest entrance, then disappears inside peeping. We are separated by just 18mm of plywood. I can hear him scurry up the tunnel, croak inside the nest chamber, then fly back out, peeping. Encouraged, she ventures in to take a look.

The next time I see this pair, they are sitting, side by side, a metre apart on a sweeping willow branch. The female edges towards the male, but he shuffles away, preferring to maintain an equal distance. Their bright-orange feet look comical as they side-step quickly in tandem.

Eventually, the male is cornered by a protruding twig and the female shuffles closer. She abruptly launches at him with her beak open. She demands a gift of a fish, which is the usual conclusion of this species' courtship. But this was too much too soon, and the male promptly flies off.

Later that day, I listen to them calling each other across the water. The sound of their whistling 'peep' pinging back and forth is sweetly hypnotic. The male flies down to catch a fish. The female fluffs up her feathers to impress him, and then flirts with a begging 'chi-chi-chi' call.

He lands headfirst and offers her his catch. She accepts this gift with quivering wings. As she gulps it down, he stands bolt upright, his tail fanned and his sharp beak pointing skywards in a posture

**During courtship, the male will present a gift of fish to the female, in what is known as a 'fish pass'. Left: bright-blue and orange plumage makes these birds easily identifiable.**



similar to his aggressive stance. Known as the ‘fish pass,’ this marks a monumental stage in their relationship when their bond is cemented. Nevertheless, it takes several days, and several more fish passes before he hovers over her and eventually lowers to mate. I notice that he crudely grasps the feathers above her eye with his beak to keep balance.

Afterwards, he catches another fish. She shuffles over, wings trembling and voice begging. But he gobbles the fish down whole. Feeling a pang on her behalf at this post-coital snub, it amuses me when she pushes him off the branch with her beak.

### LYING LOW

A few days later, I switch on the monitor linked to cameras inside the nest to find that one beautiful, shiny white egg has been laid. Kingfishers lay every 24 hours, so I settle in my hide well before dawn the next day. There is a rustle as she waddles up the tunnel, feeling her way through the darkness with her beak. She locates her egg with a gentle tap before settling down on it. I hold my breath – if I have timed this correctly, she is about to lay her second egg.

Her tail pumps up and down as she labours for an hour. Then, she stands and scuffles out of the nest, croaking. Two eggs now sit side by side in the nest. It is hard to

describe my feelings at having been just a metre away from a laying kingfisher. She goes on to lay seven pristine eggs, each as precious as pearls, and I sit alongside her for six of them. Kingfisher eggs usually hatch 20 days after the last egg is laid. The pair switch brooding duties like clockwork. The male peeps outside the entrance, as if ringing the doorbell. She waddles out, and he scuttles in.

As hatching day approaches, the female wants to spend more time incubating. In a change from the usual routine, she refuses to fly out when her mate calls to check in. Confused, he enters the tunnel to investigate, and she rushes forward, pecking him. Their beaks lock, and they twist and turn their heads as if duelling with swords. The eggs scatter. The female chases him back down the tunnel, slashing at him with her beak. Inside my hide, I gasp at the shocking brutality of this encounter.

Shortly, I notice the female becoming restless on her brood and soon after I



**THEIR BEAKS LOCK AND THEY TWIST AND TURN THEIR HEADS, AS THOUGH DUELLING WITH SWORDS.**

Robert gleefully watched the progress of the pink, alien-like hatchlings inside the nest chamber – from when the chicks first started to develop silvery pin feathers to the point they became fully-fledged individuals (above).

## WEATHER, POLUTION, AND PREDATION

We highlight the many threats encountered by kingfishers.

### COLD TEMPERATURES

Kingfishers struggle to hunt in freezing conditions and can't in frozen water. Chicks are vulnerable in cold snaps, where parents will struggle to keep them warm.

### HEAVY RAINFALL

Waterways flood, fish disperse, and water visibility can be poor during prolonged periods of rain. In these conditions, parents struggle to provide food for their young and rising water levels can result in flooded nest sites, where chicks tragically drown.

### DROUGHT

Drought conditions are increasingly problematic for kingfishers. Historic waterways dry up, reducing the food source. Over extraction of water by industry exacerbates this.

### POLLUTION

Chemical and biological pollution of rivers by industry and agriculture affects the availability of fish in the water, making long stretches of waterways uninhabitable.

### PREDATORS

Kingfishers have many predators – including cats, rats, stoats, weasels, sparrowhawks, and mink – and are particularly vulnerable at nesting time. Kingfishers may even kill each other, often by drowning, in territorial spats.

### DISTURBANCE BY HUMANS

Kingfisher nests are unintentionally destroyed when landowners maintain waterways. These birds are early nesters and maintenance should be undertaken outside the breeding season, if possible.



see the male enter the chamber with a tiny fish clasped in his beak. He rasps loudly and the female rocks briefly to one side to reveal six eggs and one freshly hatched chick.

The male rasps again to encourage the wobbly chick to feed. The blind, pink chick sways fitfully towards the fish. By some magic, it manages to align its gaping mouth with the minnow and swallows it whole.

All seven eggs successfully hatch, and the adults work tirelessly to provide food for their fast-growing and increasingly mobile young. I enjoy watching the adults' brooding and smile at the writhing pink chaos of limbs poking out from under their feathers. On occasion, the parents' short legs lose touch with the floor, and they are transported around the nest chamber like crowd-surfers.

Most nights, both adults roost in the nest with their chicks beneath them, their long beaks resting along one another's backs. But





## BLENDING IN WITH THE SCENERY

How Robert went about constructing a riverbank and nest chamber.

### THE OBJECTIVE

Kingfishers dig a long, sloping tunnel through the soil with their sharp beaks then excavate a globe-shaped chamber where the female lays her eggs. Robert wanted to replicate this by turning a shed into an artificial riverbank, with a kingfisher nest hidden within it.

### STEP 1

Inside the 1m-long nestbox, a nest chamber was created from a mould of a balloon covered in papier-mâché. This was connected to a tunnel created from a mould made from a 5cm-wide plastic drainpipe.

### STEP 2

The void surrounding the nesting chamber was filled with cement, sand, and peat, to make it seem as natural as possible.

### STEP 3

The shed was covered with the same materials. The wall of the shed was made to slope outwards and curved at the top, to mimic the overhang of a natural bank, which prevents predators from entering.



TOP LEFT  
Building work commences.

ABOVE  
The completed replica riverbank. Left: The nest chamber and tunnel were moulded from a balloon and a drainpipe.

BOTTOM LEFT  
A kingfisher's diet consists of fish and aquatic insects.

tragedy strikes when a cold front lasting three long days sweeps in, with torrential rain and freezing temperatures. Despite their best efforts to keep their large brood warm, I'm sad to discover on my next visit that three chicks have perished.

The weather improves, and the female appears intent on courting again, despite her chicks being just 12 days old. This is quite a normal kingfisher behaviour, but the male still takes a bit of convincing. Soon, I spot grains of soil on their beaks, evidence that a new nest is being built elsewhere, and then I see them mating.

The female becomes largely absent, no doubt tending to her latest clutch of eggs, and her mate is left in sole charge of the young. The chicks now sport steely silver pin feathers, which look spiky but are soft to the touch. Unusually, they won't become fully feathered until the week before they fledge. I suspect this is down to the messy nest environment.

### FLYING THE NEST

Kingfisher chicks fledge when they are around 27 days old. I arrive at the hide irrepressibly expectant. Inside the nest are three perfectly-formed little kingfishers – one has already flown the nest. The female kingfisher has now been away for nearly ten days but, as if on cue, she turns up outside the nest and calls with her mate to encourage the chicks to venture out. Inside, the youngsters scuttle around restlessly, expecting a meal, but the parents deliberately don't feed them, flying downstream instead.

In the quiet that follows, the chicks realise their parents have gone. One heads down the tunnel and launches out of the bank at rocket speed. It gets airborne just in time, its tail leaving a ripple as it skims the surface of the water.

A second chick fledges minutes later and the final chick panics, realising it is home alone. It rushes around, bumping into the



The species is most often spotted while perched on low-hanging branches above still or slow-moving water.

sides of the dark nesting chamber as it tries to find the exit. It crash-lands into the stream, rebounding off the surface before settling onto a thin reed, which bends at its weight. The chick is catapulted back into the water and has to flap, bedraggled, to the edge.

I have proudly watched these youngsters grow from tiny hatchlings, and here they are, on their first day out of the nest, mastering the skills they will need when their parents leave them to fend for themselves.

I'm surprised to see another fledgeling already trying to fish. It plunges into the water and returns with a pussy willow flower. Realising it's inedible, the bird drops the flower and dives again, this time retrieving a small twig. The male flies in with a fish in his beak. He hovers above the chicks peeping, and they follow him into some trees. **N**



**Robert E Fuller** is a naturalist, wildlife artist, and writer. Find his work at [robertefuller.com](http://robertefuller.com).

### FIND OUT MORE

Discover more fascinating facts about kingfishers on our website: [discoverwildlife.com/kingfisher-facts](http://discoverwildlife.com/kingfisher-facts)



# FROM RICHES TO RAGS

SLUMS WERE ONE OF THE GREAT SCANDALS OF THE VICTORIAN AGE. ALL TOO OFTEN, THAT SCANDAL WAS PLAYED OUT IN ONCE-ELEGANT TOWNHOUSES THAT HAD FALLEN TO RACK AND RUIN. **DAVID OLUSOGA** REVEALS THE DARK SIDE OF SOCIAL MOBILITY IN THE 19TH CENTURY

DOWN ON THEIR LUCK  
Ramshackle homes in a Newcastle slum, c1880. In one impoverished part of Tyneside, Victorian sanitary reformer Robert Rawlinson reported finding 71 people crammed into one large house.



SCAN THIS QR CODE  
FOR THE AUDIO READER

GETTY IMAGES

In 1849 a letter arrived at the offices of *The Times* newspaper. Its authors were a group of poor Londoners who lived on Church Lane and Carrier Street in what was then known as the St Giles Rookery. Their names, 54 of them in all, were listed at the end of the letter. The parish of St Giles today stands under the shadow of the Centre Point tower block, at the eastern end of Oxford Street, and includes the wealthy streets and squares of Bloomsbury. The St Giles of the 1840s was a very different place. Home to thousands of impoverished Londoners, many of them of Irish descent, it was an infamous slum, one of the capital's dirtiest and most unhealthy districts.

The letter sent by the slum dwellers to the newspaper editor, written in broken, misspelt, and phonetic English, is one of the few documents through which we can hear the voices of the very poorest of our Victorian ancestors speaking directly into the historical record. They describe, in their own words, the appalling conditions in which they were forced to subsist.

Their plaintive appeal began: "Sur, – May we beg and beseech your proteckshion and power. We are Sur, as it may be, livin in a Wilderniss, so far as the rest of London knows anything of us, or as the rich and great people care about. We live in muck and filth. We ain't got no priviz, no dust bins, no drains, no water-splies, and no drain or suer in the hole place."

Like the millions who today are forced to eke out meagre existences in the slums and favelas of the developing world, the poor of 1840s St Giles well understood the depth of their plight. They were well aware that the absence of basic amenities and elementary sanitation was the cause of their ill health. They rightly concluded that human beings should not be expected to endure such conditions and – after going on to express their entirely justifiable fear of a return of "the Colera" (the last epidemic had arrived 10 years earlier; the next was five years away) – they requested that the editor of *The Times* agree to "let us have our complaints put into your hinfluenshall paper, and... make our houses decent for Christians to live in".



RISE AND FALL  
David Olusoga  
outside the Bristol  
residence on which  
series 3 of *A House  
Through Time* is  
based. "Houses,  
as well as people,  
are capable of  
social mobility," he  
writes.

Finally, they asked: "Preaye Sir com and see us, for we are living like piggs, and it aint faire we shoulde be so ill treted. We are your respeckfull servents in Church Lane, Carrier St., and the other corts."

If the slum dwellers of St Giles exhibited any naivety in their letter, it was their seemingly earnest hope that by appealing to the wealthy and the influential, via the pages of a newspaper of record, they might inspire those in positions of power to address their concerns and alleviate their plight.

The slums were one of the great scandals of the Victorian age. In his 1898 book *The Wonderful Century*, Alfred Russel Wallace, the eminent co-discoverer of the theory of evolution by natural selection, counted Britain's slums as being "among the most terrible failures of the century", a national disgrace that even risked undermining Britain's claim to regard itself as a great civilisation. In *Bleak House*, Charles Dickens, a writer whose literary and philanthropic attentions were often directed towards the slums, lamented that in the middle decades of the century "civilisation and barbarism walked this boastful island together".

## MAZES OF MISERY

In London, as in the nation's other great cities, slums existed in various forms and multiple places – dismal enclaves of desperation and squalor, both small and large, scattered across the cityscapes. Near what is today King's Cross and St Pancras stations, for example, stood Agar Town, a maze of narrow, muddy streets lined with shanty houses. As the homes of Agar Town were built on land leased for just 21 years, they were constructed to miserably low standards. Some were even built by their impoverished inhabitants from whatever materials they were able to procure.

Agar Town was in effect a purpose-built slum. Yet if a modern visitor were able to embark upon a tour of the Victorian slums, what might surprise them most is the size and grandeur of the many slum houses. This feature of the slums, one that was commented upon by reformers, journalists, and so-called 'social explorers', had come about because some slums had emerged when middle-class districts of the cities, their streets lined with desirable residences, fell out of fashion and were abandoned by the well-to-do. Frederick Engels, who visited St Giles a few years before the residents of the Rookery sent their letter to *The Times*, recalled seeing "tall, three or four-storied

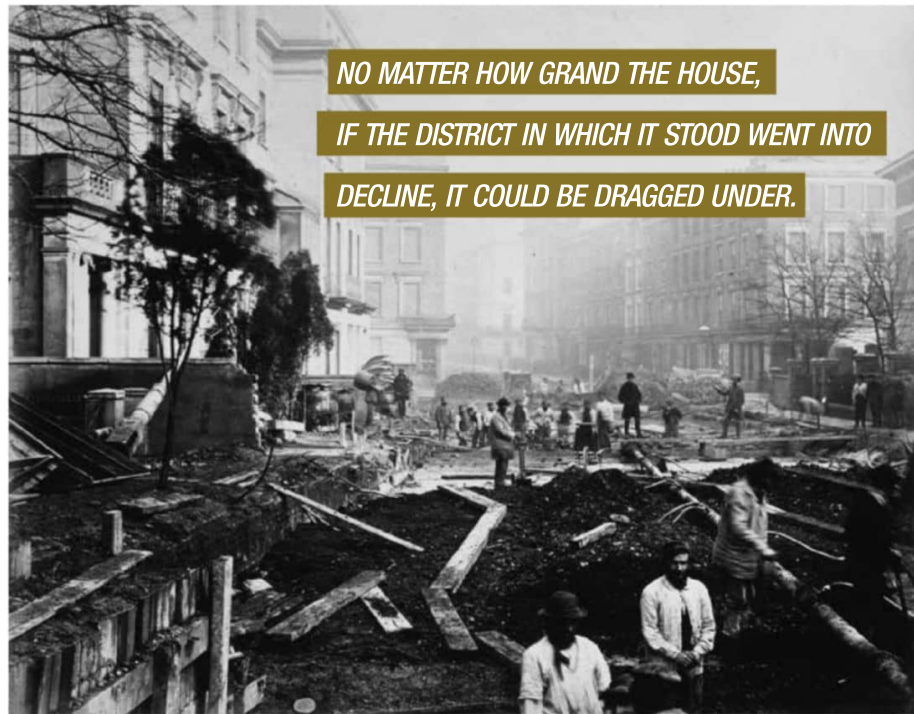


houses” that were “occupied from cellar to garret, filthy within and without, and their appearance is such that no human being could wish to live in them”.

Something of this pattern of decline and decay can be seen in the houses featured in the BBC Two series *A House Through Time*, of which I am the presenter. Series 3, which is set in Bristol and to be broadcast this spring, tells the long history of a large and elegant house in one of that city’s older districts. What this house has in common with the stars of the previous two series – 62 Falkner Street in Liverpool and 5 Ravensworth Terrace in Newcastle – is that while it was built as a home for a single wealthy family and their servants, in its later decades it was subdivided and became cheap housing for the poor.

Of the houses featured in the three series of *A House Through Time*, perhaps only 62 Falkner Street in Liverpool fell far enough down the social scale to be regarded as a true slum property. But all three houses at various moments teetered on the edge of the abyss. Across Britain in the 19th and early 20th centuries, thousands of similarly grand houses and some that were grander still, did become slums dwellings. For, no matter how architecturally elegant or well-appointed a house was, if the district in which it stood declined far enough, it was liable to be dragged under, converted into a tenement or a cheap lodging house and neglected by landlords, who were often absentees.

In 1842, Robert Rawlinson, the great Victorian sanitary reformer, reported that, “in our great sea-ports and inland manufacturing towns” stood homes that had been “originally erected for the merchant princes” but that were “now in ruins... having been the abodes of those possessing wealth, they are now the abodes of the improvident, of the vagrant, of the vicious, and of the unfortunate”. The strange effect, Rawlinson noted, was that the poor lived amid crumbling grandeur and decorations intended for the former wealthy residents. “The quaint carving on the stone-work looks out of place, the walls are half in ruins, the gables are shattered, and foul weather-stains of damp blotch the surface. The staircase is darkened, its massive hand-rail and carved balusters are crippled and broken; the once firm stairs are now rickety and dangerous; the stucco-finished plastering is blackened and in holes...”



NO MATTER HOW GRAND THE HOUSE,  
IF THE DISTRICT IN WHICH IT STOOD WENT INTO  
DECLINE, IT COULD BE DRAGGED UNDER.

#### POLLUTING INDUSTRIES

Between 1851 and the end of the 19th century, the population of Britain almost doubled. As the industrial cities burst at the seams, their poorest residents, along with the polluting industries upon which they often relied, expanded into the surrounding fields and farmland. But they also spread into earlier suburbs that had been built in previous decades on what had then been the outskirts of town. The homes built in these districts had been designed for the affluent middle classes, people who had the means to pay rents far beyond those that the poor could afford – people who in many cases had moved to the suburbs in order to escape the pollution and the unhealthiness of the inner-city districts. When cities expanded, those genteel residents fled further afield, migrating to more distant suburbs that were often linked to the city centres by the omnibuses routes and later the railways. They left behind them three and four-bedroom townhouses in elegant streets that were then inhabited by the poor.

This process was so familiar that it was commented upon not just by sanitary reformers and journalists, but also by novelists. In 1857, the writer Charles Manby Smith recounted the history of Strawberry Street, a fictional London address located in the very real suburb of Islington. When

Strawberry Street was first built in the 1820s it consisted of a “double row of two-storied dwellings” that soon attracted “professional ladies and gentlemen, whose neat brass-plates informed you that they taught drawing, painting, and japping; French, Italian, and German languages; pianoforte and singing; and the practice of all kinds of musical instruments. Then there were clerks, managers, and responsible persons employed in the city who came home regularly to their families in Strawberry Street about seven in the evening.”

However, the population of London had increased by more than a million to reach a total of around 2.5 million by the 1850s, and Strawberry Street had been wholly “swallowed up in Babylon’s bosom”. No longer a fashionable street in a stylish inner suburb, the “professional ladies and gentlemen moved by degrees further north, and their places were supplied by a new class – by tradesmen’s clerks, foremen, and overseers of workshops, and men who came home at all hours of the night and let themselves out in the dark mornings of winter long before sunrise, and who

GOING UNDERGROUND  
The Metropolitan District Railway under construction in Craven Hill, London, c1868. Industrialisation often led the middle classes to flee their well-appointed residences near city centres.

GETTY IMAGES



BLUE RUIN. Tom & Bob tasting Thompson's Best.  
London Pub by Jones & Co. April 20th 1821.

let lodgings to help to pay the rent. The whole street on both sides of the way, with the exception of a very few houses, was transformed into a third-rate business street lost all trace of its original neatness.” When a factory opened up nearby, Strawberry Street was on its way to becoming a slum.

All slums were miserable and insanitary, but districts that had fallen from respectability to impoverishment, like Strawberry Street, had specific problems. Low wages meant that the poor who were drawn to them had to spend a higher proportion of their income on rent than the middle classes – they were victims of what today is termed ‘housing stress’ or ‘rent poverty’.

To create accommodation that was within their limited financial reach, and in the hope of drawing as high a rental income as possible from their properties, landlords converted large homes that had been designed for single family habitation into tenements and lodging houses. Multiple small rooms were created out of once

elegant dining rooms and parlours, using thin partition walls. These rooms were linked together by labyrinths of dark, windowless corridors.

#### UNAVOIDABLY INSANITARY

Having never been designed for multiple occupation, the residents of subdivided tenements had no choice but to share water supplies and privies. Such communal facilities were often unavoidably insanitary, a condition made worse by the fact that when the supply of rooms that the poor could afford declined, often as a result of slum clearance schemes, yet more people were packed into houses intended for single families. In 1851, within the infamous Hillgate slum that clung onto the southern banks of the Tyne, Robert Rawlinson encountered one large house in which 71 people lived. Such overcrowding had the inevitable effect of making bad conditions worse.

Over a long enough timeframe, houses and people were capable of social mobility.

SLUMMING IT  
Regency dandies mix with Irish labourers and prostitutes in a gin palace in St Giles, London in an 1821 engraving. By 1849, conditions in the infamous slum were so bad that its residents had written to the editor of *The Times* to plea for help.

They can rise up or fall down the social scale according to the vagaries of fortune. Hundreds of thousands of houses across Britain have histories of decline and decay that in recent times have been perhaps overshadowed by our passion for renovation and gentrification. Most of the worst of the Victorian slums were long ago demolished. Yet, many homes that today are highly sought-after have – concealed behind discussions of original features and the salesmanship of estate agents – chapters of their pasts in which they became the refuges of the very poor and anything but desirable residences. **■**

David Olusoga is the presenter of the television series *A House Through Time*.

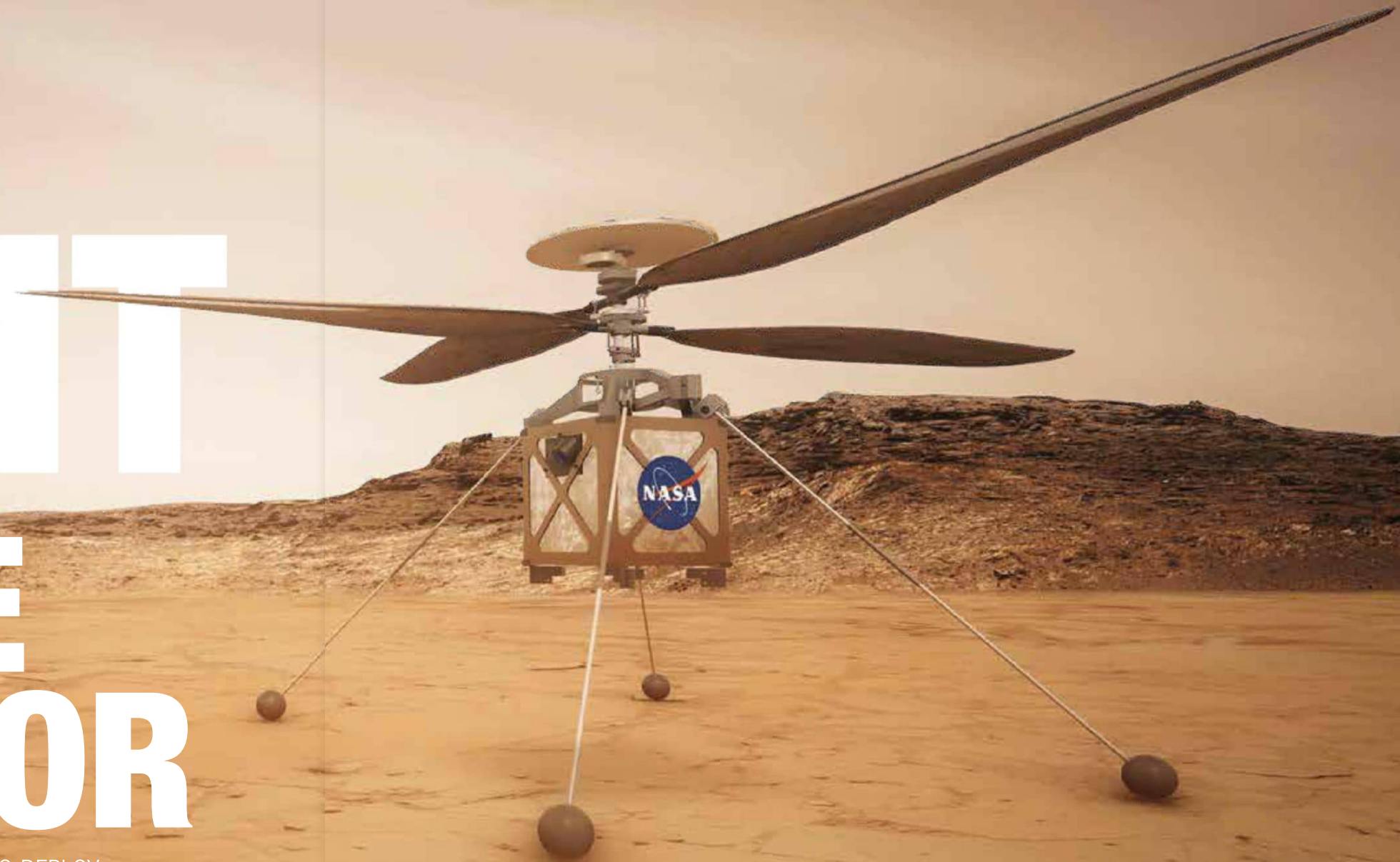
ALAMY/BBC



# FLIGHT OF THE NAVIGATOR

IN A SPACE EXPLORATION FIRST, NASA IS PREPARING TO DEPLOY  
A CHOPPER ON THE RED PLANET. FLYING IN A FRACTION OF EARTH'S GRAVITY,  
IT SHOULD BE A SIGHT TO BEHOLD

by *DR PAUL PARSONS*





**D**rones have become a familiar sight in our skies whether they are disrupting air traffic or returning glorious vistas of Earth from above. And now, for the first time, the US space agency NASA is poised to fly a drone-like helicopter in the atmosphere of another planet.

The craft, named Ingenuity, will hitch a ride to the Red Planet aboard the one-tonne Perseverance lander – NASA's latest wheeled robotic rover mission to drive across the planet's rugged surface. Perseverance will launch from Earth this summer, and will touchdown on Mars scheduled for 18 February 2021.

Flying in the alien atmosphere of another world is a feat that poses a unique set of engineering challenges. If this small technology test mission is successful, it will furnish scientists with a new and highly effective way to explore the planets and moons of our Solar System. That's because flying is a faster way to get around than ground roving. Aircraft can gather aerial imagery that's much sharper than pictures returned by spacecraft. They can also serve as scouts to identify potential targets for ground-based rover vehicles, as well as gather samples and bring them back to a central lander station for analysis.

And, of course, they can go where other probes simply can't.

"Larger Mars rotorcraft in the 5kg to 20kg class with small science payloads could access areas not reachable by rovers, and support wide-area surveys in shorter times," says Ingenuity's chief engineer Dr Bob Balaram who is based at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California. "There is also a NASA mission to explore Saturn's moon Titan with a flying lander that will arrive in the early 2030s."

The Ingenuity craft is 50 centimetres high with four blades – one pair above the other – mounted on twin, counter-rotating rotors each spanning 1.2 metres. The size of the rotors (which need to be this big for the helicopter to fly in Mars's thin atmosphere) is the main reason why a more familiar drone-like quadcopter design was rejected – such a vehicle would be simply too large to fit on the rover.

**"FLYING IN THE ALIEN ATMOSPHERE OF  
ANOTHER WORLD IS A FEAT THAT POSES A  
UNIQUE SET OF ENGINEERING CHALLENGES."**

Ingenuity is stowed beneath the body of Perseverance, from where it will be dropped onto the surface of Mars, probably a couple of months into the mission. The rover will then drive 100 metres away to minimise collision risk, and the two will exchange radio signals to 'pair up' – a bit like pairing wireless earbuds to your phone – before the rover sends the command for Ingenuity to make its inaugural flight. It will likely be what Balaram calls a 'mutual selfie' – the two vehicles taking pictures of one another as the helicopter rises to a low hover and then lands again.

#### MARS EXPLORER

Ingenuity carries a black-and-white navigation camera and a 4,208 x 3,120-pixel colour camera, comparable to what might be found on a mobile phone. Images are beamed by short-range radio link to Perseverance, which then relays them to one of a number of NASA spacecraft in Mars orbit, from where they are transmitted back to Earth. "Multiple images may be stitched into a panorama at some point using ground software tools," says Balaram.

The helicopter isn't going to make any actual scientific observations, however. Instead, the focus is to return engineering data from the test flights that will hopefully validate the technology, or at the very least, provide valuable feedback to refine future designs.

The primary mission plan is up to five flights over 30 days, though this may be extended. The maximum horizontal range of the flights will be about 300 metres with a ceiling altitude of ten metres and a max flight time of 90 seconds, after which the helicopter's six lithium-ion batteries need recharging. A solar panel handles this mounted directly above the rotor blades. A full charge takes a whole Martian day to complete, and two-thirds of the power stored is needed to keep the aircraft's electronics warm during the bitterly cold Martian night, when temperatures can plunge to -100°C.



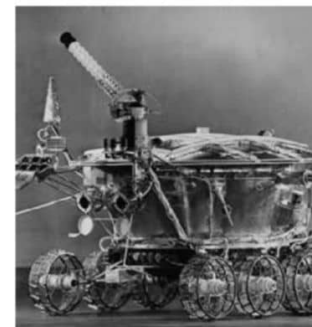
Ingenuity, visible lower centre, attached to the Perseverance rover.

#### LAND, SEA, AND AIR

### All-terrain exploration of the Solar System

#### LUNOKHOD

The first wheeled rover to explore the surface of another world was the Soviet Lunokhod 1 probe, which landed in the Moon's Sea of Rains on 17 November 1970. Resembling a bathtub on wheels, its instruments included cameras and radiation detectors. It survived on the lunar surface for 322 days.



#### VEGA

The helium-filled Vega balloons, each measuring 3.5 metres across, were two unpowered aircraft dropped into the atmosphere of Venus by the Soviet Union in 1985. They floated 50km above the planet for 46 hours before they succumbed to the corrosive atmosphere and their failing batteries.



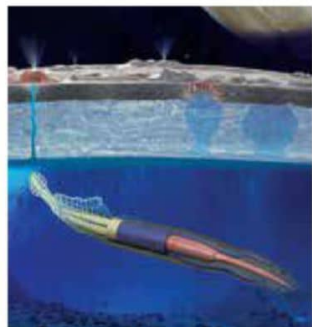
#### DRAGONFLY

Due to leave Earth in 2026, NASA's Dragonfly is an octocopter drone that will drop into the skies of Saturn's largest moon, Titan, in 2034. With a nuclear battery on board, it will spend nearly three years surveying Titan, where conditions may resemble those in which life first emerged on Earth.



#### EUROPA SUBMARINE

There is good evidence that Jupiter's moon Europa harbours an ocean of liquid water beneath its icy surface, heated by the constant flexing of Jupiter's gravitational pull. Some engineers have come up with designs for submersibles to explore this ocean, although none have yet been selected to fly.



NASA/JPL, MASON PECK/CORNELL UNIVERSITY, NASA/GSFC/ARIZONA STATE UNIVERSITY, GEOFFREY LANDIS/WIKIPEDIA





Testing Ingenuity in the lab.

The low temperature is only the beginning of the problems facing a would-be Martian aviator. Aircraft take off using 'lift', an upward force created as air passes over a curved aerofoil. On a plane, the aerofoil is the wing; on a helicopter, it's the rotor blades. But the surface density of Mars's atmosphere is just one per cent of Earth's. A cubic metre of air at sea level on Earth weighs 1.2kg, but on Mars that figure drops to only a few grams – roughly equivalent to the tenuous atmosphere on Earth at an altitude of 30,000 metres (100,000 feet). To generate enough lift to fly from such thin air means the engine has to work overtime, whereas helicopters on Earth typically spin their blades at 500 revolutions per minute (rpm). On Mars, you need to crank this up to around 2,500rpm.

The weight of the craft is kept to an absolute bare minimum for the same reason. For example, each pair of rotor blades weighs just 56 grams – despite measuring over a metre in length. "Carbon composite layups within a foam core matrix were used to achieve lightweight but stiff blades," says Balaram. In total, Ingenuity weighs in at just 1.8 kilograms – that's less than a couple of bags of sugar. Balaram has even worked out the best time of day to fly the helicopter on Mars – mid-morning, as it turns out, roughly 11 a.m. By this time, the craft has been warmed by the Sun after the chilly Martian night, but the air is cool, keeping its density as high as possible and its wind speeds low, while the batteries still have a healthy charge. "After we get the first couple of flights under our belt, I'm sure we will try to fly in the afternoon and do more exploratory things, but the most conservative thing we can do is to pick a mid-morning flight," he says.



The Mars Perseverance rover will travel to the Red Planet with Ingenuity.

"IN TOTAL, INGENUITY WEIGHS IN AT

JUST 1.8 KILOGRAMS, – THAT'S LESS THAN A COUPLE

OF BAGS OF SUGAR."

## MARS ROCKS, PERSEVERANCE ROLLS

THE NEW ROVER MISSION IS SET TO REVOLUTIONISE THE HUNT FOR PAST LIFE ON MARS.

Ingenuity will fly to the Red Planet with NASA's Perseverance rover mission. It is scheduled to blast off from Cape Canaveral aboard an Atlas V rocket in a three-week launch window beginning on 17 July 2020. The one-tonne wheeled vehicle, which is about the size of a small car, is due to touch down in Mars's Jezero Crater during February 2021. Mars is a dry, barren world today. Between 3.5 and four billion years ago, it was suspected to have enjoyed a warm, wet climate suitable for fostering life. The Jezero Crater landing site is believed to have been the floor of a great lake at this time, awash with liquid water, and Perseverance will scour the site for any remaining biological signatures. The initial mission span is one Martian year (about 1.9 Earth years), during which Perseverance is expected to drive around 200 metres a day, examining soil and rocks. The rover is equipped with a coring drill which it'll use to extract rock samples, leaving them in canisters along its route for recovery by a future sample return mission.

NASA/KSC, NASA/JPL



# HOW INGENUITY WORKS

## SOLAR PANEL

It takes a day in the Martian sunlight for the solar panel to recharge the helicopter's lithium-ion batteries.

## ANTENNA

The radio antenna receives communications from, and returns images and data to, the Perseverance rover.

## ROTOR BLADES

The two counter-spinning rotors measure 1.2 metres in length, yet weigh just 56 grams each.

## MOTORS AND CONTROL

These power the blades and adjust their pitch to control thrust and steer the vehicle.

## LANDING LEGS

The flexible legs have the elasticity to absorb jolts as the helicopter touches down after each flight.

## FUSELAGE

To power it, this sealed box contains the helicopter's electronics and batteries. It's also filled with CO<sub>2</sub> gas for insulation.

## SPECIFICATIONS

**Mass**  
1.8kg

**Height**  
50cm

**Rotor span**  
1.2m

**Rotor speed**  
2,300-2,900rpm

**Max altitude**  
10m

**Batteries**  
6x Sony Li-ion, delivering 220W power

**Max flight time**  
90s

**Range per flight**  
300m

**Max flights per day**  
1

**Mission duration**  
30 days

**"IF THE HELICOPTER'S TRIALS ON MARS ARE A SUCCESS,  
THEN IT WILL BE A GENUINELY HISTORIC ACHIEVEMENT –  
THE FIRST EVER POWERED FLIGHT BEYOND EARTH."**

## ON TRIAL

The team tested their design inside the JPL's Space Simulation Chamber, a 25-metre-high, eight-metre-wide cylindrical test vessel in which the atmosphere could be precisely tuned to replicate the aerodynamic conditions on Mars. However, the low pressure was only one of the peculiarities of flying on Mars that had to be modelled. They still needed to account for the planet's gravity, which is only 0.38 (just over a third) of that found on Earth. They came up with a novel solution.

"A gravity off-load device was installed into the chamber and was used to provide a compensating force on the vehicle to account for the difference in gravity between Earth and Mars," says Balam. It means attaching a lightweight thread to the top of the vehicle, which they pulled tight just enough to lift 0.62 of the helicopter's weight on Earth – leaving the remaining 0.38 (its weight on Mars) to be lifted aerodynamically by the rotors.

Aside from demonstrating the basic feasibility of flight on Mars, these ground tests were crucial for another reason – allowing the team to fine-tune the Guidance, Navigation, and Control (GNC) software that will have to pilot the helicopter on Mars. When the first real Martian flights begin, the light-travel time from Earth to Mars will be many minutes, making it impossible for controllers to steer the craft remotely. The commands from the Earth's ground control consist of a set of waypoints – coordinates selected by controllers – which the GNC software will follow while taking account of the

stream of real-time data flooding in from the helicopter's sensors. These include gyroscopes, accelerometers, a navigation camera, an altimeter, and an inclinometer which measures the aircraft's tilt.

"Waypoints consist of an x-y position, a height above ground, a vehicle heading, and the desired time to arrive at each point," Balam says. To test the software, his team even set up multiple high-energy lamps inside the simulator to recreate sunlight illumination at the Martian surface, as well as fans to simulate flight in windy conditions. On top of all this, Ingenuity must also be a spacecraft, certified to survive the stresses of launch, the seven-month journey to Mars during which it will be subjected to radiation and the harsh vacuum of interplanetary space, and then finally wracked by the high g-forces and scorching 2,200°C heat of entry, descent, and landing through Mars's atmosphere.

If it works and the helicopter's trials on Mars are a success, then it will be a genuinely historic achievement – the first-ever powered flight beyond Earth. The expertise gained will also lay the groundwork to fly bigger and better aircraft, capable of carrying a full payload of scientific instruments to explore the skies of distant worlds.

As Balam puts it: "It's kind of a Wright Brothers' moment on another planet." **S**

**Dr Paul Parsons** (@NasaProPlus) is a science journalist and author of *Ten Short Lessons In Space Travel*.

NASA/JPL

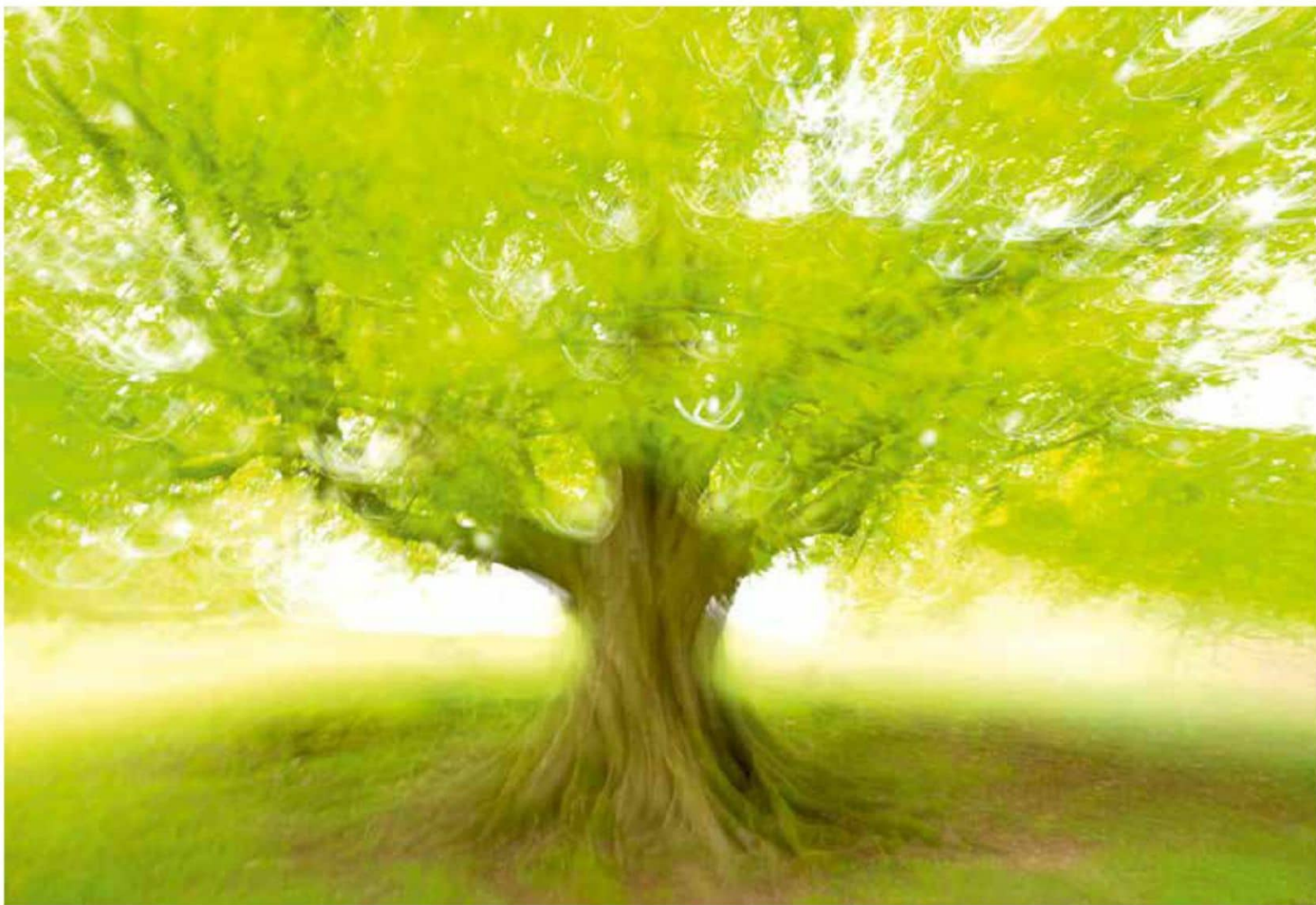


# BRINGING HOME THE WILD

Photos by  
Ross Hoddinott

THIRTY-FIVE YEARS AGO, ROSS HODDINOTT'S FAMILY MOVED TO A FORMER FARM IN A QUIET CORNER OF CORNWALL AND DEDICATED THE LAND TO WILDLIFE. TODAY, A HABITAT IS FLOURISHING WHERE FIELDS ONCE STOOD





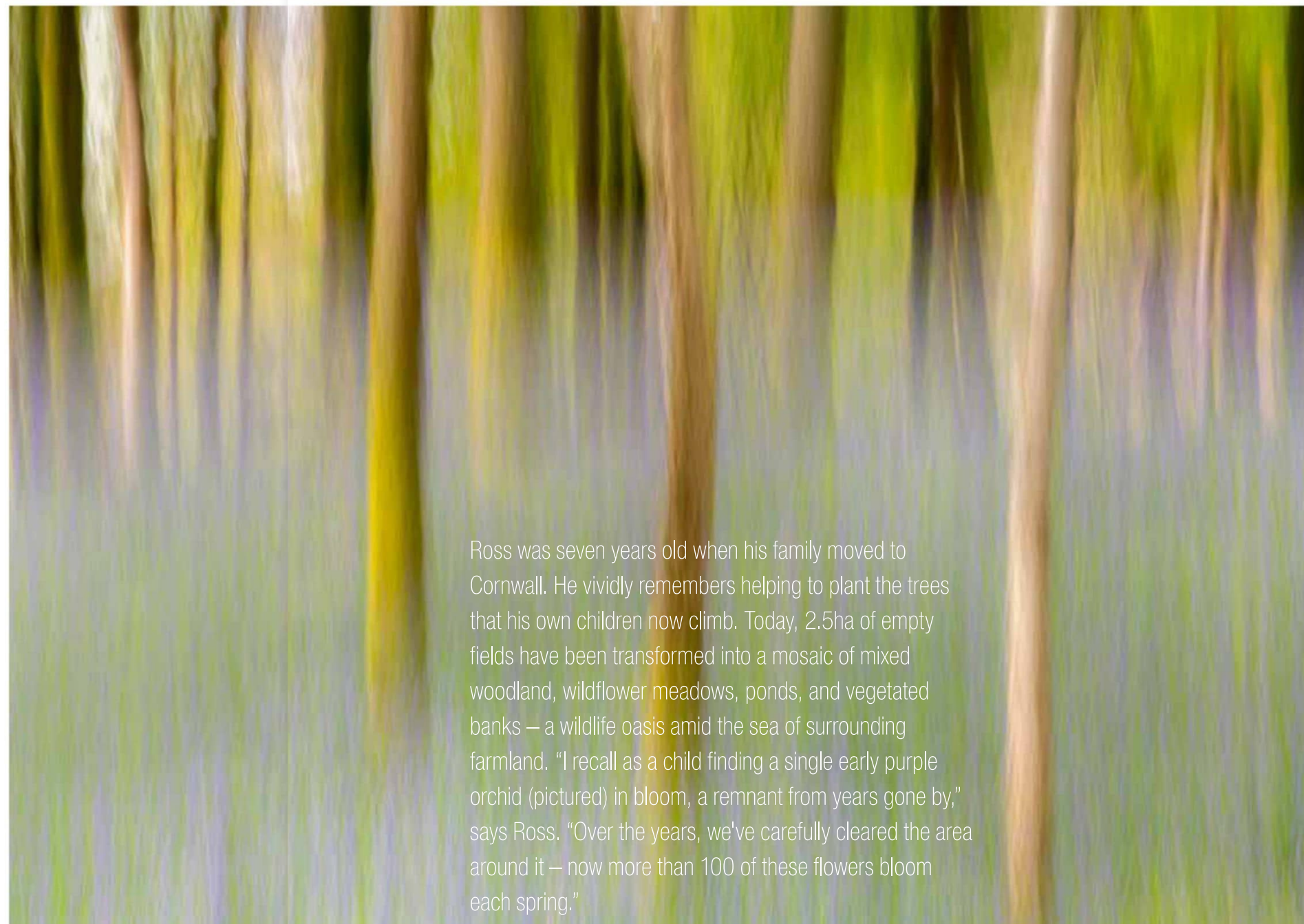
↑ **ABOVE** Only a few isolated trees, such as this ancient beech, punctuated the open expanse of farmland in the 1980s. Today, the land is a blend of old and young — the twisted trunks of veteran trees contrast with the stands of new growth.

← **LEFT** In recent years, the trees have started the natural process of dropping branches. The woodpiles created in the process provide shelter for invertebrates and an ideal habitat for autumn-sprouting fungi.



The ponds that Ross helped to dig, aged 11, were colonised by wildlife almost immediately. “It was amazing how quickly an ecosystem became established,” he recalls. “We had several breeding dragonfly species in the first summer, including broad-bodied chasers (pictured) and common darters.”





Ross was seven years old when his family moved to Cornwall. He vividly remembers helping to plant the trees that his own children now climb. Today, 2.5ha of empty fields have been transformed into a mosaic of mixed woodland, wildflower meadows, ponds, and vegetated banks — a wildlife oasis amid the sea of surrounding farmland. “I recall as a child finding a single early purple orchid (pictured) in bloom, a remnant from years gone by,” says Ross. “Over the years, we’ve carefully cleared the area around it — now more than 100 of these flowers bloom each spring.”



**LEFT** The wide, stony banks that once served as field boundaries are swathed in plants such as hard ferns. Left to their own devices, the fern’s evergreen fronds have started to spread, springing up among the leaf litter on the woodland floor.



**ABOVE** Five years after planting the trees (a mix of beech, sycamore, birch, oak, and horse chestnut), Ross’s parents introduced a large number of bluebells, as well as wood anemones and wild garlic. “The bluebells have taken fantastically,” says Ross. “The colour and structure of a young bluebell wood is great for painterly shots like this — allow half a second exposure, then pan from top to bottom as you release the shutter.”





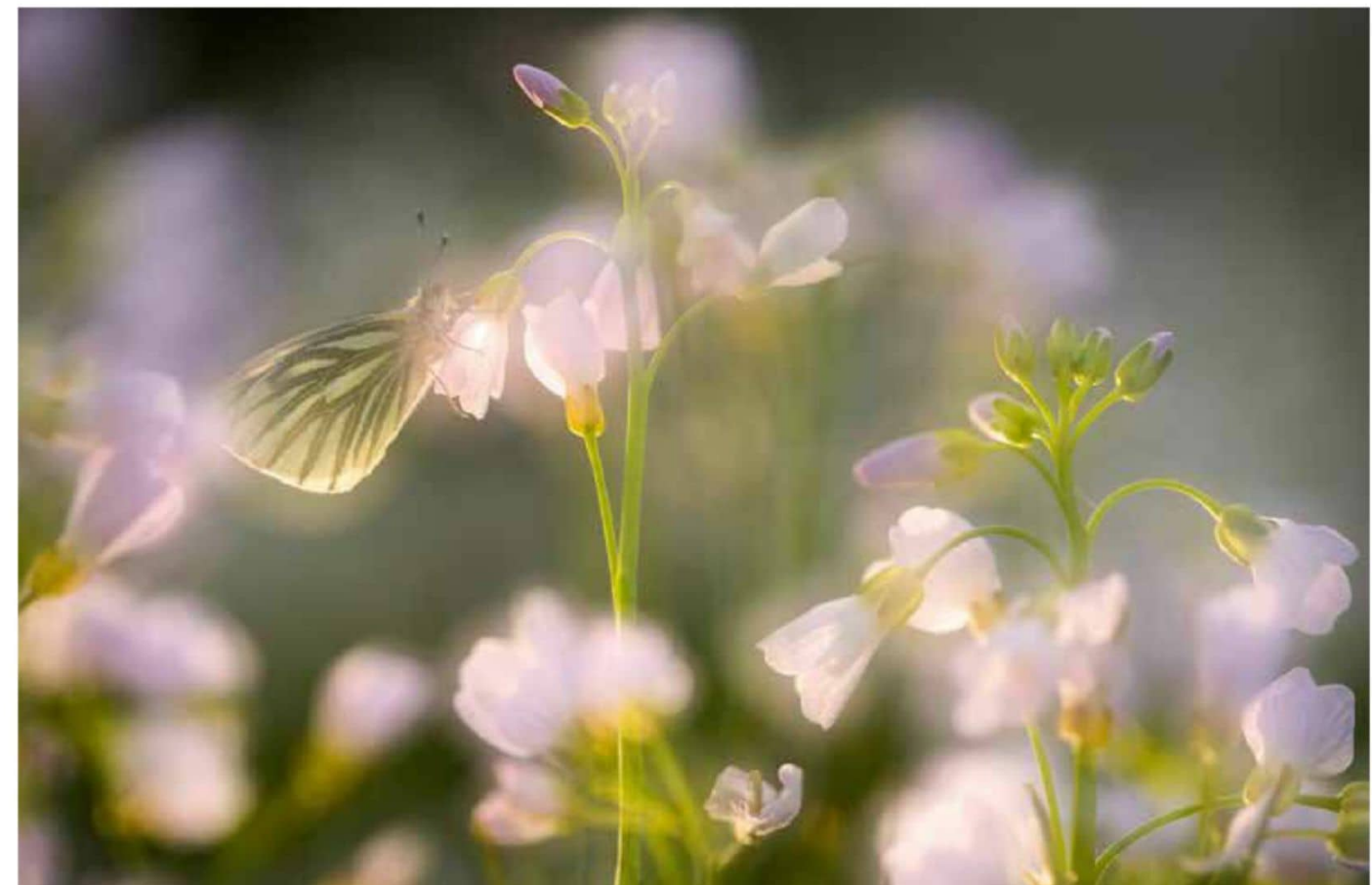
**OPPOSITE** Good numbers of damselflies – here common blues – emerge as adults in spring, having completed their final moult on waterside grass stems. Like their dragonfly cousins, the local damsels were quick to take possession of a new home – Ross has recorded seven species breeding here.



**RIGHT** Snowdrops (pictured here with a double exposure against the sun) explode from the woodland floor in February.



**BELOW** Also known as lady's smock, cuckooflower is a foodplant of the green-veined white butterfly. The plant loves damp habitats, and is flourishing at the pond edges.







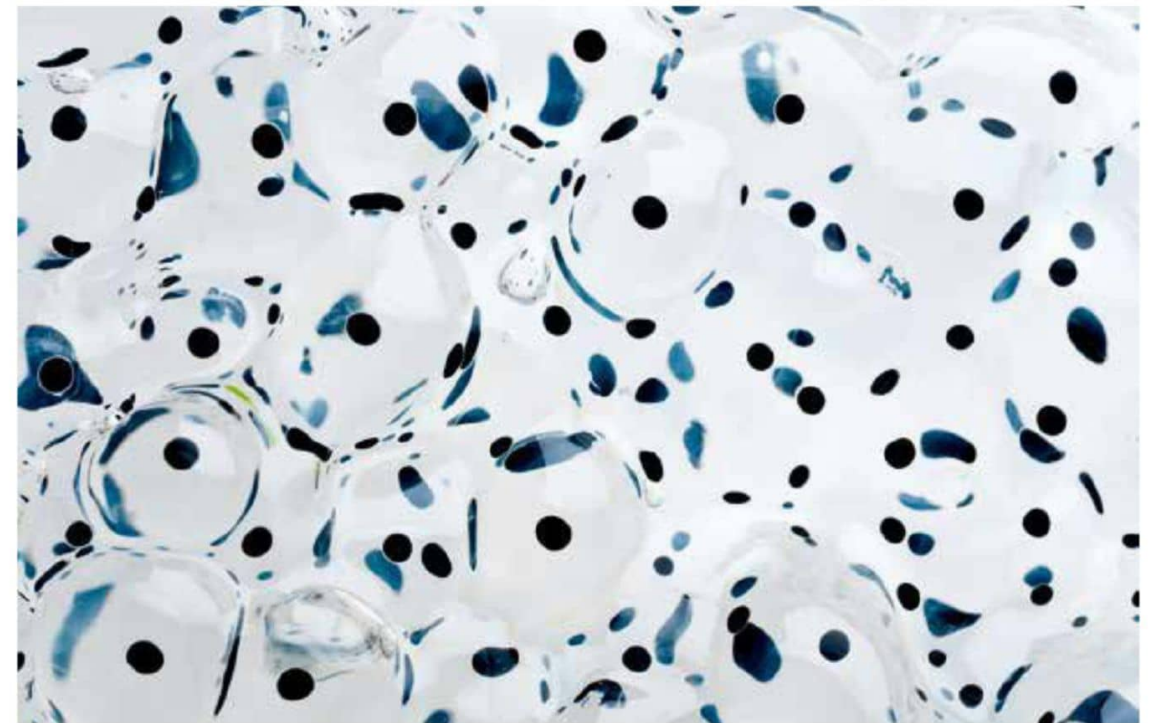
**Ross Hoddinott** is a wildlife and landscape photographer, as well as a photography tutor specialising in Devon and Cornwall.  
[rosshoddinott.co.uk](http://rosshoddinott.co.uk)



**ABOVE** Moss is often overlooked, but it's a fundamental part of a woodland ecosystem. This close-up reveals the plant's fruiting bodies – capsules packed with spores – glistening with raindrops.



**RIGHT** The resident frog population began with a handful of spawn from a neighbour. "Most years, we get at least 100 adult frogs and toads, diving beetles and newts, but this year the spawn was completely devoured by ducks," says Ross. "It's a bit frustrating, but when you welcome in the wild, you sometimes have to let nature take its course."





# HENRY V's GREATEST VICTORY

HENRY V IS BEST KNOWN AS THE BRILLIANT WARRIOR WHO WON THE DAY AT AGINCOURT. HE WAS ALSO A MASTER DIPLOMAT, SAYS **ANNE CURRY**, AND HE PROVED AS MUCH IN THE CITY OF TROYES 600 YEARS AGO WHEN HE WAS DECLARED HEIR TO THE FRENCH THRONE





In Troyes on 21 May 1420, Charles VI, king of France, did something truly remarkable: he recognised the English claim to his throne. Acknowledging King Henry V as his rightful heir was nothing short of a humiliation for Charles's nation. The 'Hundred Years' War' appeared to be over. The English – personified by their young, vigorous king, Henry V – stood triumphant. At least for now.

To appreciate the significance of this moment, it pays to take a closer look at what happened at Troyes six centuries ago. For more than 80 years, the rulers of England had waged war with the Valois kings of France, claiming that they had a stronger right to the French crown. Over the intervening decades, both sides' fortunes had ebbed and flowed. Now, five years after Henry had led his first English invasion of France, there appeared to be an outright winner.

By sealing the Treaty of Troyes, King Charles was not only acknowledging Henry as his rightful successor but also Henry's heirs. In other words, the two crowns were to be, for all time to come, ruled by the same king – the king of England. The treaty had swept aside the claim to the French throne of not only the Dauphin (or heir apparent) Charles, the son of Charles VI, but also of all the other male members of the Valois royal house. Worse still for the French, Henry V was to be regent while awaiting his accession to the French throne because Charles VI had suffered repeated mental crises since 1392.

To cement this remarkable settlement Henry married Charles's daughter, Catherine, in Troyes on 2 June. She was crowned at Westminster Abbey on 23 February

1421, and in the following banquet, table decorations proudly proclaimed: "Through this fine marriage, war will cease."

So how did Henry pull off the coup of persuading (or forcing) the French to accept the English as rightful kings of France? For Shakespeare, there was a simple explanation: Agincourt. In his 1599 play *Henry V*, Shakespeare draws a direct link between Henry's most famous victory, secured in October 1415, and his diplomatic triumph at Troyes.

Henry was indeed one of England's great military leaders. But if the years between Agincourt and the Treaty of Troyes teach us anything, it is that Henry was so much more than a brilliant soldier. He was also a talented

HENRY WAS A BRILLIANT LEADER IN PEACE

AND WAR, AND THOSE QUALITIES YIELDED

EXTRAORDINARY RESULTS AT TROYES.

diplomat and a ruthless opportunist. In short, he was a brilliant leader in peace and war, and those qualities yielded extraordinary results at Troyes.

It's important to remember that Henry was also helped by fatal vendettas within France in the early years of the 15th century, which seriously compromised attempts to fight off English invasions. At the heart of French divisions lay a bloody rivalry between two factions battling for control of the mentally ill king: the Armagnacs, who initially rallied behind Charles VI's younger brother, Louis, Duke of Orléans, and the Burgundians. Tensions had been rising for years, but they

exploded in November 1407 when John the Fearless, Duke of Burgundy ordered the assassination of Louis. Civil war followed and soon both sides were appealing to the English for military support. Henry V's decision to go to war in France in 1415 was surely motivated by an ambition to exploit the chaos engulfing his opponents.

A BITTER SIEGE

But Shakespeare was right in emphasising the longer term effect of Agincourt. Henry's victory in 1415 made the French reluctant to face him in battle again. As a result, there was no major check to the campaign of systematic conquest that Henry began in Normandy on 1 August 1417. By the summer of 1418, almost all of Lower Normandy was under English control. The Norman capital, Rouen, proved a more difficult nut to crack, as a bitter six-month siege reveals. But once Rouen had accepted English rule in January 1419, much of Upper Normandy surrendered to Henry without resistance.

All the while, Henry showed skill in winning the hearts and minds of his new subjects by fanning their pride in Norman identity and separatism, reviving folk memories of the old Anglo-Norman ducal past. He also ensured strong military control within his newly conquered duchy, and encouraged both his administrators and soldiers through grants of land within it – a Norman Conquest in reverse, so to speak.

In the face of this determined English advance, French divisions grew wider still until in late spring 1418 they reached a new nadir with a Burgundian attack on Paris. Not only did the Burgundians seize control of the capital, but they also murdered



HANDS IN MARRIAGE  
As part of the negotiations at Troyes, Henry V secured himself a wife: Catherine, daughter of King Charles VI of France. Here, a 15th-century miniature shows the couple marrying in 1420.



BATTLEFIELD FRANCE  
Our map shows the region fought over by Henry V and the French factions in the early 15th century

Armagnac leader Bernard d'Armagnac and forced his successor as Armagnac leader, the Dauphin Charles, into flight. As for the king, he fell under the control of the Duke of Burgundy and was moved to Troyes for his 'safety'.

Once Henry V had taken Rouen, the Duke of Burgundy was willing to negotiate with the English. Henry too was keen to come to a settlement to consolidate his success. At the subsequent meeting at Meulan in June 1419, where Henry first set eyes on Catherine, the two sides came close to agreeing on terms: the restoration to Henry of lands in south-west France granted to Edward III in the Treaty of Brétigny (1360), plus Normandy, and Henry's marriage to Catherine with a large dowry.

The settlement was never enacted. At the last minute, the Duke of Burgundy and the Dauphin chose to work towards a joint

TIMELINE

HENRY V's BATTLE FOR FRANCE



MID-AUGUST 1415  
Henry V invades France. The Normandy port of Harfleur surrenders to the English on 22 September.

An illustration showing Harfleur in 1449–50. In 1415, Henry V had besieged the Normandy port.

25 OCTOBER 1415  
Henry V secures a spectacular victory over French forces at Agincourt.

15 AUGUST 1416  
Their defeat ends French efforts to besiege Harfleur by land and sea in a naval battle in the mouth of the Seine. With Harfleur secure and following an alliance with Sigismund, emperor-elect, Henry prepares for a new invasion.

1 AUGUST 1417  
Henry V lands at the mouth of the river Touques in Lower Normandy.

19 SEPTEMBER 1417  
Henry captures Caen and establishes his administration in the city. Leading his army southwards, he takes key locations such as Alençon, dissecting Lower Normandy.



Burgundians massacre Armagnacs as civil war erupts in France.

FEBRUARY 1418  
After putting up stubborn resistance, the strategically significant castle of Falaise surrenders to Henry. The Duke of Gloucester is sent westwards into the Cotentin, and the Duke of Clarence eastwards towards the Seine to complete the conquest of Lower Normandy.

ALAMY/GETTY IMAGES

BRIDGEMAN/GETTY IMAGES/BATTLEFIELD DESIGN



John the Fearless's murder strengthened Henry V's hand in France

JULY 1418  
Henry lays siege to the Norman capital, Rouen, which surrenders on 19 January 1419. Much of Upper Normandy subsequently falls to Henry without resistance. Negotiations begin for a territorial settlement.

1 JULY 1419  
Negotiations fail, with the Burgundians and Armagnacs moving towards a reconciliation in order to unite against Henry. The English begin to move towards Paris.

10 SEPTEMBER 1419  
The Dauphin's henchmen assassinate John the Fearless, Duke of Burgundy. Reconciliation between the Burgundians and Armagnacs is now impossible. Henry V can exploit this situation and negotiate a dynastic settlement.



Charles VI of France had few answers to Henry's military might and diplomatic cunning.

21 MAY 1420  
In the treaty sealed at Troyes, Charles VI recognises Henry as his heir.

2 JUNE 1420  
Henry marries Catherine, daughter of Charles VI, in the church of Saint-Jean-au-Marché in Troyes.

31 AUGUST 1422  
Henry dies at the castle of Vincennes to the east of Paris. His body is brought back through Normandy to England for burial in Westminster Abbey on 7 November.





HENRY WAS A MASTER OF

REALPOLITIK. BY GAINING

CHARLES'S RECOGNITION,

HE BOOSTED HIS OWN

CREDIBILITY IN FRANCE.

BATTLE FOR POWER

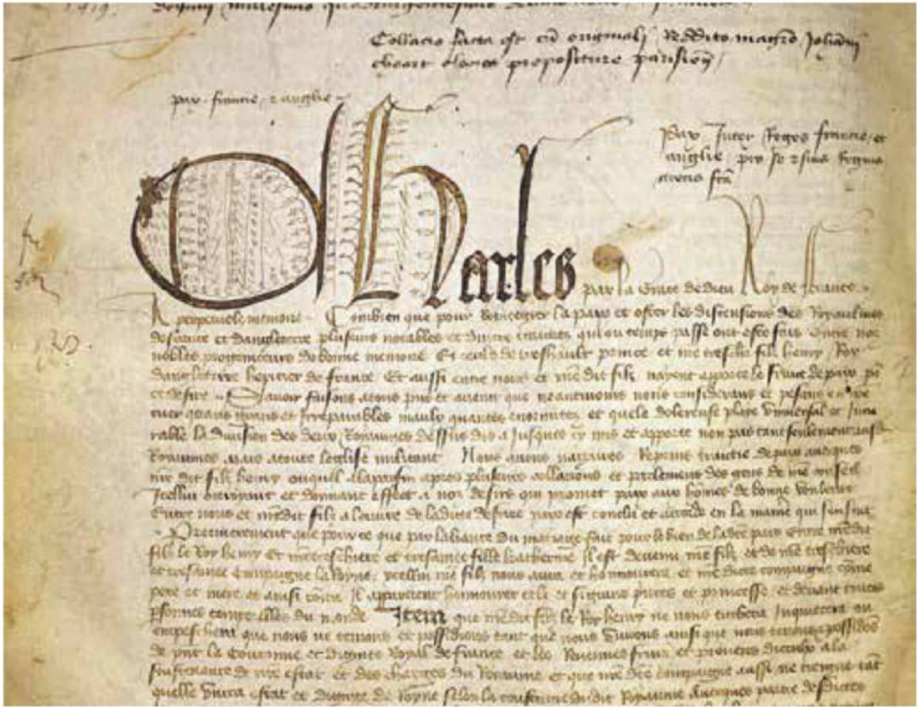
**A 15th-century miniature of the battle of Agincourt. Over the following four years, Henry V would exploit this victory brilliantly, boxing the French into a diplomatic corner from which they couldn't escape.**

and his party; furthermore, the Dauphin had broken his solemn agreement with Duke John and was no longer worthy of any dignity or obedience.” The assembly declared the proposed treaty terms to be “most convenient, most profitable, and most necessary”. By 9 April, the preliminaries of the treaty were agreed. All that remained was for Henry to come to Troyes for final discussions and ratifications, and for the public sealing of the treaty.

Throughout the negotiations, Henry had shown himself a master of realpolitik. The salient element of the treaty was not merely that Charles VI had recognised Henry as heir to the French crown, but that Henry was willing for Charles to retain the throne until his death. While Henry had enjoyed much military success to date, he was all too aware that he was in no position to take the throne by conquest. By gaining the French king's recognition, Henry reasoned that he was boosting his credibility and therefore, the chances of acceptance by the French people. He agreed that there would be no English ‘takeover’ of France and that he would rule according to French practice. The king and queen would be respected, supported, and would remain in France.

Intriguingly, Henry appears to have formulated the idea of such a delayed inheritance some years earlier. After the fall of Harfleur in September 1415, Henry had summoned the then Dauphin Louis to single combat. The winner, Henry suggested, should be acknowledged as the heir to Charles VI, but Louis never responded to the offer.

ALAMY



GAME-CHANGER

**An original copy of the treaty of Troyes. Had the treaty “succeeded in the longer term”, writes Anne Curry, “the history of Europe might have turned out very differently”.**

By the time of the sealing of the treaty of Troyes, Charles VI was not expected to live for much longer. Henry would surely be king soon. Even as regent, he knew that he could rely on the support of the Burgundians in their search for revenge. Not surprisingly, the treaty included several clauses in their favour, as well as committing Henry to the destruction of their Armagnac enemy.

Henry was aware of potential resistance within France to the terms of the treaty. As a result, the wider political community, as well as the main parties to the treaty, were required to pay public oaths to uphold the treaty and to promise to obey Henry as heir and as king. What's more, Henry deemed it wise that there should be a formal summons to the Dauphin to face justice for the murder of Duke John, following proper French practice. After making a ceremonial entry together into Paris, deliberately timed for Advent Sunday, Charles VI and Henry held a *lit de justice* (a specific kind of court session). Hardly surprisingly, the Dauphin did not respond to the summons and was declared an outlaw.

TRIUMPH AND DEATH

There were Frenchmen and women, even beyond the Armagnac group, who did not accept the validity of the treaty. For others, it offered real hope of peace after

SHUTTERSTOCK

many years of upheaval. As regent, Henry did not disappoint, both in his wise and sensitive government and in his successful military campaigns against the Dauphin's supporters. Ironically, though, Henry's end came through military actions. In 1422, just two years after sealing the treaty, he contracted dysentery – supposedly while besieging Meaux – and died on 31 August at the castle of Vincennes. He would never inherit the French throne despite his triumph in the Treaty of Troyes. Charles VI would follow him to the grave just two months later. And so it was that the infant Henry VI, born to Henry and Catherine on 6 December 1421, became the first king of the double monarchy of England and France. He was crowned king in Paris on 16 December 1431.

At first, it appeared that the Treaty of Troyes might continue to thrive despite the death of its formidable creator. John Duke of Bedford, regent in France for the young Henry VI, was a well-respected warrior. Paris remained particularly loyal to the treaty. Soon after the death of Henry V, the leader of its mercantile community promised his successor that in return for aid against the Dauphinists harrying Paris, saying “We shall abide by what is right, and be ready to obey the commands and wishes of our sovereign lord.” It helped enormously that

Duke Philip of Burgundy made clear at Henry V's death that he stood fully by the Troyes settlement: “I am ready to commit myself and do everything necessary for the good of the kingdom of France and to maintain the treaty.”

The Dauphin only became a formidable opponent after he had himself crowned as king of France in the traditional crowning place of Reims in July 1429. That gave him credibility beyond his supporters and a real chance of challenging the ‘English’ king of France. His achievement was down to the intervention of Joan of Arc, a key figure in lifting the siege of Orléans in May 1429 and as iconic in French history as Henry V is within the English national story. Faced with increasing opposition and the defection of the Burgundians to Charles VII in 1435, Henry VI's regime in France crumbled.

But that should not detract from the agreement in Troyes in May 1420. Henry V was responsible for one of the most amazing treaties in history. Had it succeeded in the longer term, with the same king ruling England and France, the history of Europe might have turned out very differently. The treaty proved ineffective once the English had lost most of their French lands in the early 1450s, but it was not until 1801 that kings of Great Britain stopped calling themselves kings of France.

While history remembers Henry V as a warmonger, he was also a peacemaker, and a skilled one at that – aiming to resolve centuries of conflict. His vision, as expressed in the treaty terms, was that “all divisions, hatred, and rancours between England and France should cease and that the two realms should enjoy in perpetuity peace, tranquillity, affection, mutual agreement, and firm friendship”. Henry may be most celebrated for what he achieved on the battlefield of Agincourt, but the treaty of Troyes was undoubtedly his greatest victory. **■**

**Anne Curry** is emeritus professor of medieval history at the University of Southampton. Her books include *Henry V* (Penguin Monarchs, 2015)

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# THE DIRTY TRUTH OF EATING **GREEN**

WITH VEGAN LIFESTYLES BECOMING MORE POPULAR AND FOOD MANUFACTURERS PRINTING CARBON FOOTPRINTS ON THEIR PACKAGING, WE WONDER WHAT IT REALLY TAKES TO EAT A DIET THAT DOESN'T DAMAGE OUR PLANET

by COLIN BARRAS

ILLUSTRATION TOM STRAW





**“EVEN WHEN YOU ACCOUNT FOR TRANSPORTATION, THE SPANISH TOMATO HAS A LOWER CARBON FOOTPRINT THAN THE BRITISH TOMATO.”**

LEFT  
UK-grown tomatoes need to be grown in heated greenhouses. This gives them a bigger carbon footprint than Spanish tomatoes that are transported to the UK.

Look at a packet of Quorn mince, and you’ll discover that a 75g serving contains 10.9g of protein, 3.4g of carbohydrates, and 0.4g of saturated fat. Later this year, a glance at the packet will tell you something else: producing the 75g serving released the equivalent of 0.16kg of carbon dioxide into the atmosphere.

Since 2011, Quorn Foods has been working with researchers at Sheffield Hallam University, and non-departmental public body Innovate UK to calculate the carbon footprint of its meatless products. It has had the information certified by the Carbon Trust, and plans to add it to product packets later this year. Doing so should “better [inform] people who want to understand the environmental impact of the foods they buy,” says Quorn Foods. But will the move help Britons understand and lower their dietary carbon footprint – and how close can we get to a zero-carbon diet?

Judging by the volume of media coverage on the subject, consumers are increasingly interested in cutting their carbon footprints. Focusing on food is an excellent place to start. According to a 2012 study, food-related processes release about one-fifth of the UK’s total annual greenhouse gas emissions, or 167 million tonnes of CO<sub>2</sub>e. Greenhouse gas emissions are often measured in CO<sub>2</sub>e – carbon dioxide equivalent – for simplicity. This is a single measure that includes the warming potential from all greenhouse gases emitted by a given industry, including carbon dioxide, methane, nitrous oxides, and so on.

**NO MEAN FEAT**

There’s another reason why Brits wanting to lower their carbon footprint should begin with their diet: it’s one aspect of our lives over which we have a relatively high degree of control. “Many people are in rental accommodation so there’s little they can do

to make their home more energy efficient, and they don’t necessarily have much choice about transportation to and from work,” says Prof Peter Scarborough at the University of Oxford, who researches population, nutrition and sustainability. “But diet is absolutely something they can choose to change.”

It doesn’t necessarily mean that footprint labelling on food will help UK consumers lower the carbon cost of their diet. For several years now, nutritional ‘traffic light labels’ have been added to some foods. Scarborough has conducted research into the way UK consumers respond to such traffic light labelling but has found that it is difficult for people to use the information to make decisions.

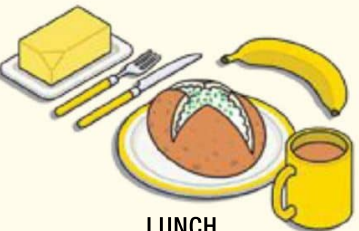
If, for instance, one product has two ‘green lights’ and two ‘red lights’, a consumer might legitimately wonder whether it is healthier than a rival product with one ‘green’, one ‘red’ and two ‘ambers’. Likewise, a consumer standing in the food aisle might find it difficult to quickly work out whether the carbon footprint of a pre-prepared Bolognese sauce is higher or lower than the carbon footprints associated with a tray of minced beef, an onion, some fresh basil, and a bag of fresh tomatoes.

Speaking of tomatoes, they highlight another problem with carbon footprint

GETTY IMAGES ILLUSTRATION: PAUL BUTT

# THE CARBON COST OF FOOD

It is surprisingly difficult to work out the carbon footprint associated with our diets: it depends as much on where and how the food we buy was grown as what we actually eat. For instance, some beef comes from calves raised within dairy herds, while other beef comes from calves raised in non-dairy herds. Researchers argue the ‘dairy beef’ carries a significantly lower carbon footprint because the herd is effectively growing two products – milk and beef – lowering the carbon footprint of both. The following is a very rough guide of the carbon cost of food, using the same data that Dr Graham Horgan at Biomathematics and Statistics Scotland and his colleagues are using in their algorithm.

| HIGH FOOTPRINT                                                                                                                                                                                                                                                                                                                                                                                                                                                               | MEDIUM FOOTPRINT                                                                                                                                                                                                                                                                                                                                                                      | LOW FOOTPRINT                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p><b>BREAKFAST</b><br/>Two rashers of bacon (0.6kg CO<sub>2</sub>e)<br/>Two small sausages (0.4kg CO<sub>2</sub>e)<br/>Two eggs (0.2kg CO<sub>2</sub>e)<br/>Portion of baked beans (0.1kg CO<sub>2</sub>e)<br/>Cup of tea with full-fat dairy milk (0.05kg CO<sub>2</sub>e)</p>                                                                                                         |  <p><b>BREAKFAST</b><br/>Porridge with full-fat dairy milk (0.24kg CO<sub>2</sub>e)<br/>Two slices of wholegrain toast with butter (0.27kg CO<sub>2</sub>e)<br/>Cup of tea with full-fat dairy milk (0.05kg CO<sub>2</sub>e)</p>                                                                   |  <p><b>BREAKFAST</b><br/>Bowl of muesli with soya milk (0.13kg CO<sub>2</sub>e)<br/>Glass of orange juice (0.4kg CO<sub>2</sub>e)<br/>Cup of black tea (0.01kg CO<sub>2</sub>e)</p>                                                                                                                                                                       |
|  <p><b>LUNCH</b><br/>Roast beef sandwich with tomato, lettuce, and mayonnaise (1.78kg CO<sub>2</sub>e)<br/>Packet of crisps (0.1kg CO<sub>2</sub>e)<br/>Pot of yoghurt (0.2kg CO<sub>2</sub>e)<br/>Can of fizzy drink (0.1kg CO<sub>2</sub>e)</p>                                                                                                                                        |  <p><b>LUNCH</b><br/>Baked potato with butter and cheese (0.73kg CO<sub>2</sub>e)<br/>Banana (0.21kg CO<sub>2</sub>e)<br/>Cup of coffee with full-fat dairy milk (0.09kg CO<sub>2</sub>e)</p>                                                                                                     |  <p><b>LUNCH</b><br/>Butternut squash and carrot soup* (0.18kg CO<sub>2</sub>e)<br/>Nuts and dried fruit (0.25kg CO<sub>2</sub>e)<br/>Cup of black coffee (0.05kg CO<sub>2</sub>e)</p>                                                                                                                                                                   |
|  <p><b>DINNER</b><br/>Portion of cod (0.9kg CO<sub>2</sub>e)<br/>Portion of chips (0.1kg CO<sub>2</sub>e)<br/>Portion of peas (0.02kg CO<sub>2</sub>e)<br/>Two scoops of ice cream (0.4kg CO<sub>2</sub>e)<br/>Total: 4.95kg CO<sub>2</sub>e<br/>Over the course of a year, this is the same as a petrol car travelling roughly 14,200km** (London to Perth, Australia is 14,470km)</p> |  <p><b>DINNER</b><br/>Seafood pasta in a tomato sauce* (1.31kg CO<sub>2</sub>e)<br/>Rice pudding (0.3kg CO<sub>2</sub>e)<br/>Total: 3.2kg CO<sub>2</sub>e<br/>Over the course of a year, this is the same as a petrol car travelling roughly 9,197km** (London to Quito, Ecuador is 9,214km)</p> |  <p><b>DINNER</b><br/>Portion of rice (0.36kg CO<sub>2</sub>e)<br/>Portion of lentil and mushroom curry* (0.14kg CO<sub>2</sub>e)<br/>Pot of yoghurt (0.2kg CO<sub>2</sub>e)<br/>Total: 1.72kg CO<sub>2</sub>e<br/>Over the course of a year, this is the same as a petrol car travelling roughly 4,943km** (London to Montreal, Canada is 5,200km)</p> |

\*Not including carbon footprint associated with minor ingredients including herbs and spices.  
\*\*Assuming the average five-seater petrol car emits about 127g of CO<sub>2</sub> per kilometre.





labels: apparently identical food items can differ drastically in their carbon costs. University of Manchester professor Adisa Azapagic and her colleagues published a study last year on the environmental impact of vegetable consumption in the UK, including the carbon footprints that different vegetables carry. Azapagic's team concluded that putting one kilo of UK-grown fresh tomatoes on the British dining table produces 12.5kg CO<sub>2</sub>e. Perhaps surprisingly, putting one kilo of foreign-grown tomatoes on the table produces just 1.3kg CO<sub>2</sub>e. The explanation for this, says Azapagic, is that the climate in the UK means tomatoes must be grown in greenhouses that are heated mainly with electricity. Spanish tomatoes don't carry this carbon cost because tomato plants thrive in warm Mediterranean fields.

This neatly punctures another popular misconception: that imported products must have a higher carbon cost than local food because of transportation. A lot of food is transported by boats and lorries rather than planes, and in environmental terms the cost of transportation is usually tiny compared with the cost of actually growing the food. "Even when you account for transportation, the Spanish tomato still has a much lower carbon footprint than the British," says Azapagic.

ABOVE

Insects are a healthy source of protein with a lower carbon footprint than meat.

### VEGETATIVE STATE

So, if eating local won't make a difference, what will? The answer is to eat less meat, says Scarborough. In 2014, he and his colleagues calculated the carbon footprints of various British diets. A meat-eater diet released between 4.7 and 7.2kg CO<sub>2</sub>e each day depending on how much meat it contained – the vegan diet released just 2.9kg CO<sub>2</sub>e. Vegetarians and people who eat fish but not meat came out in-between: their daily diets released 3.8kg and 3.9kg CO<sub>2</sub>e, respectively.

One reason meat has such a high carbon footprint is that livestock is typically fed grain that could instead be given directly to humans. Animals then use the energy in that grain for all manner of processes including maintaining body temperature and keeping their internal systems functioning. A relatively small fraction goes into building the muscle and other tissue we consume as meat, making the process of 'growing' meat extremely inefficient – although Scarborough says the problem isn't as bad for small animals like chickens. "You don't have to feed a chicken anywhere near as much [as you must feed a cow] to get a kilogram of meat," he says.

Even so, all meat carries a relatively high carbon cost. Perhaps in recognition of this fact there has been an upsurge in the number of vegans in the UK. According to some estimates, there are 600,000 British vegans today – four times as many as in 2014. But vegans in the UK are still outnumbered roughly 100 to 1 by non-vegans. Even if people are convinced of the environmental benefits of going vegan, they may be reluctant to make that shift. They might even balk at the idea of replacing lamb or beef with low-carbon alternatives: swapping a beef burger for a locust burger, for instance, or trying what might be the next food trend: lab-grown meat.



LEFT

Meat consumption is falling; there are four times as many vegans in the UK today, as there were six years ago.

**"MOST OF THE EMISSIONS [ASSOCIATED WITH CATTLE] ARE FROM ENTERIC METHANE," KEBREAB SAYS. "SO, IF YOU ARE ABLE TO REDUCE THE EMISSIONS BY 50 PER CENT – THAT'S ABSOLUTELY HUGE."**

Prof Ermias Kebreab, a biologist and ecologist at the University of California, Davis, thinks that there might be a way to sidestep this reluctance. If we are unwilling to change our own diets, then perhaps the solution is to change the diets of the animals many of us eat instead.

Last year, he and his team demonstrated that by supplementing animal feed with about 1 per cent by weight of a particular strain of seaweed, they could half the amount of methane that cows belch into the atmosphere – known as 'enteric methane'. This is because the seaweed reduces the ability of microbes in the cow's stomach to generate the methane: the animals burp out larger quantities of hydrogen gas instead, which has an indirect, smaller impact on global warming. "Most of the emissions [associated with cattle] are from enteric methane," Kebreab says. "So, if you are able to reduce the emissions by 50 per cent – that's absolutely huge."

Encouraging as it may seem, Scarborough says it doesn't reduce the carbon footprint of beef and lamb to the level of beans or pulses. Supplementing livestock diet with seaweed can't change the fact that most of that animal feed consists of grain we could eat ourselves. Some consumers might protest that the beef on their plate comes from 'pasture-raised' cows that ate grass rather than grain – but Scarborough says many of these animals are actually brought into cow sheds at night and given grain.

PETER BOLTER, GETTY IMAGES X2



TOP

Quorn Foods has been working with researchers to calculate the carbon cost of its meatless products.



CARBS

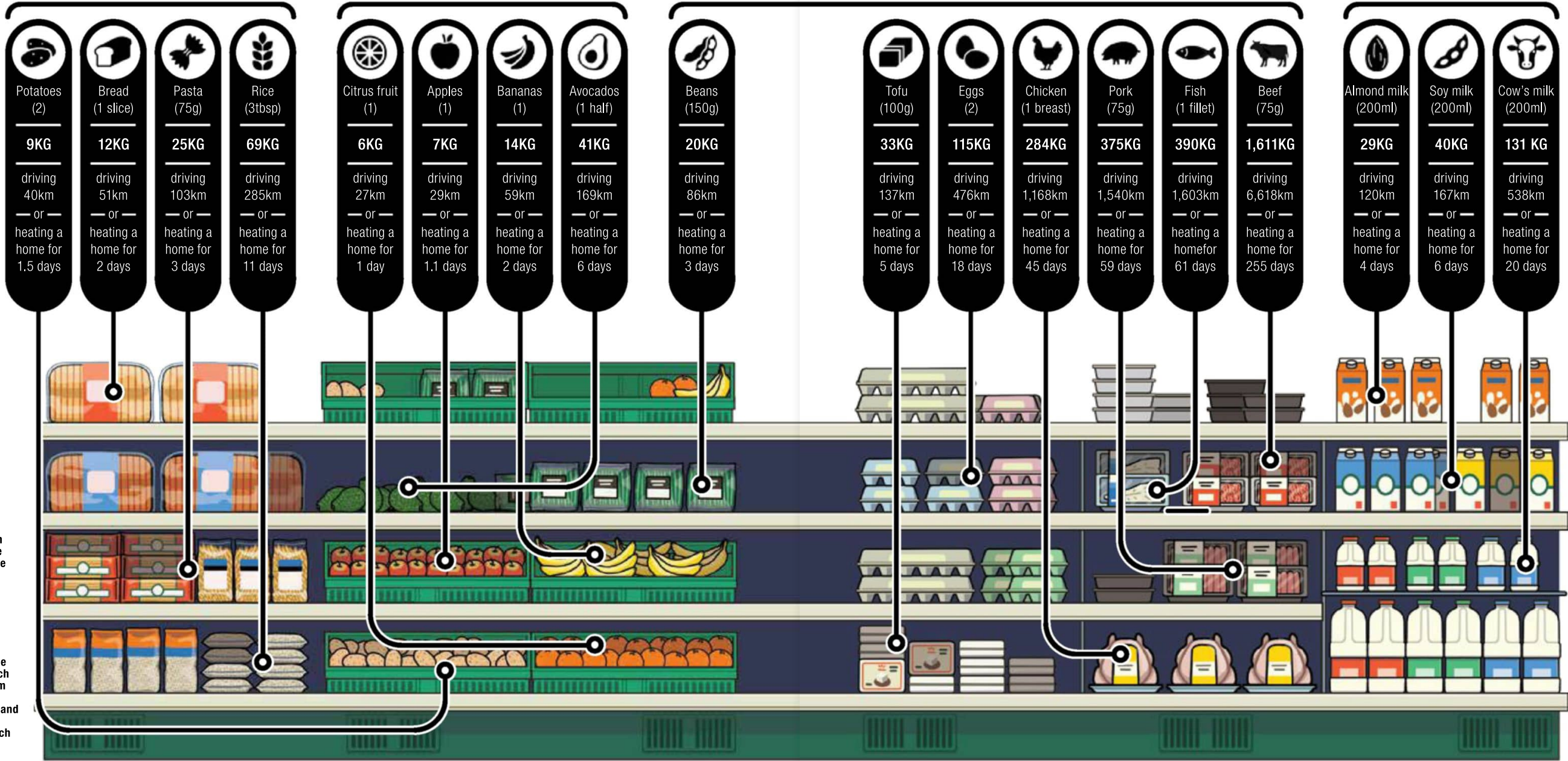
FRUIT

PROTEINS

DAIRY

Greenhouse gas emissions:

Equivalent of:



In each case we've calculated the consumption over an entire year, and have assumed three to five servings a week.

**CREDIT**  
The data in this infographic was calculated using the BBC's climate change food calculator, which is based on data from researchers at the University of Oxford and the Agroecology and Environment Research Division in Zurich, Switzerland.

ILLUSTRATION PAUL BUTT



HAVE YOUR STEAK AND EAT IT, TOO

At this point, one might be forgiven for concluding that Scarborough and researchers like him will only be satisfied when all of us have adopted a vegan diet. He stresses that this is far from being true. In fact, he says that some scientific models suggest it is slightly more efficient to have small numbers of livestock in the agricultural system than none. In manageable quantities, for instance, animal manure is a useful fertiliser. “The problem is that the number of animals in the food system right now is overwhelming it,” he says.

It’s not about giving up meat, says Scarborough, but eating far less of it. Doing so is good for animal welfare too. If we eat less meat, we can ‘afford’ – from an environmental perspective – to allow farm animals to live a free-range life rather than raise them through intensive farming. In other words, British consumers should be able to adopt a diet with good environmental and ethical credentials – if they are willing to eat no more than about one portion of meat per week.

Dr Graham Horgan and his colleagues at Biomathematics and Statistics Scotland designed an algorithm ([muncher.aws.bioss.ac.uk](http://muncher.aws.bioss.ac.uk))

that aims to nudge people towards making those kinds of dietary changes. It assesses someone’s food shopping list and, using data on the range of carbon footprints associated with each product, suggests relatively small tweaks that should reduce the carbon cost while still meeting nutritional requirements. For instance, the first thing the algorithm does is increase or reduce the quantity of any given item on the list by up to 50 per cent. Then it considers adding small quantities of foods not on the shopping list – a tin of mackerel, for example – that can provide key nutritional requirements at a relatively low carbon cost. “Our approach was to try to avoid saying ‘cut out red meat altogether’ and simply say ‘eat less red meat,’” says Horgan. “I feel that might be more acceptable to consumers.”

Just by making these changes, about 50 per cent of people in a 2016 study published by Horgan and his colleagues could continue to eat meat but also reduce the carbon footprint of their diet to a level where it released only 3.1kg CO<sub>2</sub>e per day. This isn’t too much higher than the 2.9kg CO<sub>2</sub>e per day for a *vegan diet* that Scarborough calculated. Horgan now wants to test whether the algorithm can have a real-world impact on the dietary choices made by average British consumers.

Beyond cutting down on meat there is at least one more thing consumers can do to lower their dietary carbon footprint: learn to appreciate the value of food. Some estimates suggest that the food we buy but then throw away adds up to 214 calories per

person each day. But an analysis published earlier this year concluded that the problem is worse than that. Dr Monika van den Bos Verma and her colleagues at Wageningen University & Research in the Netherlands found that each of us, on average, actually wastes 527 calories each day. Alarming as this conclusion is, she points out that it also represents a golden opportunity. “Yes, it’s a bigger problem than we thought,” she says. “But that means if we can solve it, it’s a bigger solution as well. That’s a big ‘if’, but I think we can do it.”

Right now, there isn’t much stigma associated with throwing away bread that has gone stale, or bananas that have overripened. But what we deem socially acceptable can change relatively rapidly, as we’ve seen in recent decades with public perceptions of smoking. With more awareness about the time and energy that goes into producing food, we might be more willing to turn stale bread into breadcrumbs, or overripe bananas into banana muffins. Or we might simply become better at purchasing just the food we need, rather than bulk-buying

products and throwing food away.

Scarborough agrees that attitudinal shifts to food are possible. “People assume food habits are stuck for life, that people don’t change – but it’s absolutely not true,” he explains. “If you look at the food we consume now versus 60 years ago, it’s very different.”

Consumers should be able to adopt lower-meat diets and waste less food, not least because this is what most British people have done for centuries. So if we can make those changes, will it bring the zero-carbon diet into view? In one sense, the answer is a firm no: we will always need to use energy to produce even the most frugal of diets. But eventually it may be possible to offset most – or even all – of the emissions associated with our food, particularly if more of us reduce our meat consumption. This is partly because with less demand for pasture it will be possible to ‘rewild’ agricultural land, and an acre of forest can absorb far more carbon than an acre of pasture. No one has run the numbers, but it’s an intriguing idea, says Scarborough. “The question of whether the food system as a whole can be zero-carbon over the long run? That’s an interesting one.”

Colin Barras is a freelance science writer and editor based near Ann Arbor, Michigan.

Q&A

YOUR QUESTIONS ANSWERED

- What’s the largest flying animal?
- Why does light travel faster than sound?
- What did dinosaurs evolve from?
- Will a curry bring on labour?
- How can I protect myself from the coronavirus while shopping?
- Why do dogs go round in circles before they poo?
- Why do locusts swarm?
- Where does soil come from?
- Is it possible to have no sense of smell?

E-mail your questions to [questions@sciencefocus.com](mailto:questions@sciencefocus.com) or submit on Twitter at [@sciencefocusQA](https://twitter.com/sciencefocusQA)

OUR EXPERTS

|                                                              |                                                                  |                                                          |
|--------------------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------|
| <b>DR ALASTAIR GUNN</b><br>Astronomer, astrophysicist        | <b>DR CHRISTIAN JARRETT</b><br>Neuroscientist, psychology expert | <b>DR JEREMY ROSSMAN</b><br>Virologist                   |
| <b>DR STEVE BRUSATTE</b><br>Palaeontologist, dinosaur expert | <b>DR EMMA DAVIES</b><br>Chemistry expert, science writer        | <b>DR HELEN PILCHER</b><br>Biologist, science writer     |
| <b>RORY GALLOWAY</b><br>Science writer, radio producer       | <b>LUIS VILLAZON</b><br>Science/tech writer                      | <b>ABIGAIL BEALL</b><br>Science/space writer             |
| <b>STEPHANIE ORGAN</b><br>Science/health writer              | <b>ALEX FRANKLIN-CHEUNG</b><br>Environment/climate expert        | <b>PROF ROBERT MATTHEWS</b><br>Physicist, science writer |



ERICA REYNOLDS, COVENTRY

IS THERE ANY LINK BETWEEN HANDWRITING AND PERSONALITY

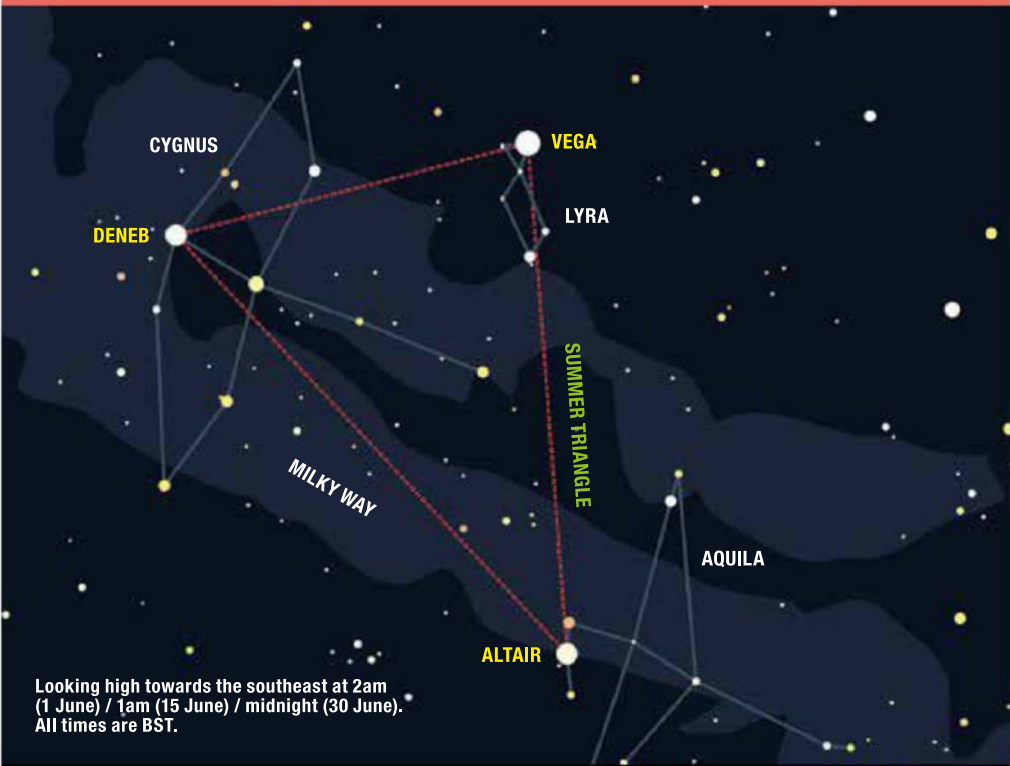
I remember as a child being discouraged from allowing my handwriting to slope backwards – I was warned my relaxed letters would be taken as a sign of an idle personality. Handwriting analysis, or ‘graphology’, which has its modern roots in the theories espoused by a group of 19th-Century French Catholic clergy, makes many such claims about what is revealed by a person’s writing style, some more eyebrow-raising than others. Unsurprisingly, perhaps, contemporary psychology views graphology as a joke – indeed, the claim that our handwriting reveals our personality traits is listed in 50 Great Myths Of Popular Psychology, an influential book written by a team of US psychologists. That said,

specific claims linking aspects of handwriting to personality continue to emerge, even in mainstream psychology journals. For example, in a 2016 study carried out by researchers in Uruguay, hundreds of people completed personality tests and then signed their name. The researchers reported that a larger signature correlated with having more social bravado among men, while a bigger signature correlated with having narcissistic traits are in women. So, there might be some very specific situations in which the way you write can be revealing. The Uruguayan researchers suggest that signatures are a special case because they serve as a form of self-expression.

ILLUSTRATION DANIEL BRIGHT



# ASTRONOMY FOR BEGINNERS



## HOW DO I FIND THE SUMMER TRIANGLE?

**WHEN:** JUNE, JULY, AND AUGUST; NORTHERN HEMISPHERE

When people think about stargazing, they might imagine it involves memorising all the constellations, but sometimes the best star patterns to look for aren't constellations at all. An 'asterism' is any pattern of stars that's not one of the official 88 constellations. And one of the easiest asterisms to spot, especially during the northern hemisphere's summer months, is the Summer Triangle.

The Summer Triangle is made up of three bright stars: Vega, Deneb, and Altair. Each is in a different constellation: Lyra the harp, Cygnus the swan, and Aquila the eagle respectively. The brightness of these stars means that the asterism is visible even in places with light pollution.

The Summer Triangle is visible for most of the year, but in July and August

it shines directly overhead at around midnight. June is also a good time to see it because it rises above the eastern horizon at around 11 p.m. so that you can use the horizon as a reference. At this time, the sky won't be completely dark, so only the three stars in the triangle will be visible. Later in the night, fainter stars will become visible, too (see the diagram above).

Vega is the brightest of the trio, so look for this star first. To the lower left and lower right, you'll find Deneb and Altair, respectively. The trickiest thing about identifying the triangle is that it spans quite a large area of sky, but once you've seen it, you'll learn how to recognise it.

If you live somewhere with low light pollution, you can use the Summer Triangle as a map to the Milky Way. Pick a night with little or no moonlight (the few days surrounding the new moon on 21 June), wait until it is darkest (between 12:30 a.m. and 1:30 a.m.), find the Summer Triangle, and look for a band of light passing through it. You're looking edgewise into the flat disk of stars that makes up our Galaxy. **AB**

# TOP 10

**SMARTEST COUNTRIES**  
(as measured by Nobel laureates per capita)

**1 FAROE ISLANDS**  
1 Nobel laureate (1 per 48,497 people)

**2 SAINT LUCIA**  
2 (1 per 90,945 people)

**3 LUXEMBOURG**  
2 (1 per 303,864)

**4 SWITZERLAND**  
28 (1 per 304,162)

**5 SWEDEN**  
32 (1 per 318,224)

**6 ICELAND**  
1 (1 per 353,574)

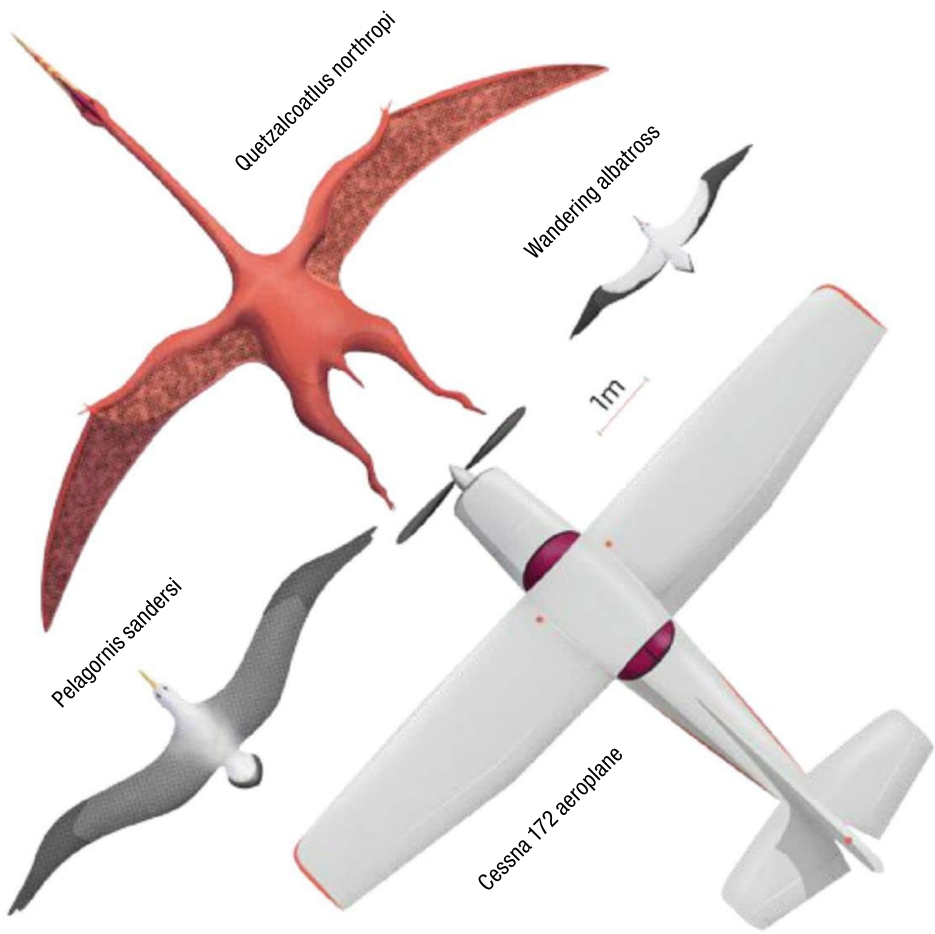
**7 AUSTRIA**  
22 (1 per 402,138)

**8 NORWAY**  
13 (1 per 408,795)

**9 DENMARK**  
13 (1 per 445,957)

**10 UNITED KINGDOM**  
132 (1 per 503,704)

**Note:** We've included all six Nobel Prizes (Chemistry, Literature, Peace, Physics, Physiology or Medicine, and Economics). Some laureates are counted twice because the official Nobel website mentions them in relation to two countries. Faroe Islands are included as an autonomous territory within the Kingdom of Denmark. Population stats are for 2018 from [data.worldbank.org](https://data.worldbank.org).



SAM CROSSLEY, BRADFORD

## WHAT'S THE LARGEST FLYING ANIMAL?

In terms of wingspan, the largest birds are those adapted for soaring, long-distance flight. The wandering albatross is the current record holder, with a maximum recorded wingspan of 3.7 metres, but prehistoric animals were even more impressive. Pelagornis sandersi, a bird which lived 25 million years ago, had an estimated wingspan of up to 7.4 metres. Like albatrosses, it probably took to the air by running downhill into a headwind or launching off cliffs. However, even P. sandersi was dwarfed by some of the pterosaurs, those flying reptiles from the time of the dinosaurs. The largest so far discovered is Quetzalcoatlus northropi, which may have weighed more than 200kg with a wingspan of 11 metres – that's as wide as a Cessna 172 aeroplane! Computer simulations have shown that Q. northropi could soar at 130km/h and stay aloft for up to ten days. **LV**

TOBY GRAHAM, SHREWSBURY

## WHY DOES LIGHT TRAVEL FASTER THAN SOUND?

According to Einstein's Special Relativity, the speed of light has a unique status: it's a fundamental feature of our Universe, representing the maximum speed at which information can travel from place to place. As such, nothing can match the 300,000km/s achieved by light travelling through a vacuum – least of all sound, which being waves of compression and expansion in a substance doesn't even exist in a vacuum. That said, light can be slowed down by being passed through transparent materials – by around 33 per cent in the case of glass. Even so, it still zooms through glass around 50,000 times faster than sound waves. **RM**



GETTY IMAGES ILLUSTRATIONS: DANIEL BRIGHT





CHRIS MCMULLON, BARNHAM, WEST SUSSEX

## WHY DOES MY DOG GO ROUND IN CIRCLES BEFORE SHE POOS?

A 2015 study in the Czech Republic and Germany reported that dogs tend to poo along the north-south axis of the Earth's magnetic field. It presents the intriguing possibility that circling behaviour is their way of gauging the orientation of the magnetic field before they get down to business. But this research is controversial, and other researchers have been unable to reproduce the findings. It's more likely that dogs are acting out an ancestral behaviour to flatten the grass and drive away insects before they squat. **AV**

## CROWDSCIENCE

Every week on BBC World Service, CrowdScience answers listeners' questions on life, Earth, and the Universe. Catch up online at [bbcworldservice.com/crowdscience/](http://bbcworldservice.com/crowdscience/)



## WHY DO LOCUSTS SWARM?

Locusts have caused famine and starvation for as long as humans have been farming. Swarms can appear suddenly, and proceed to decimate crops over huge areas. Since June 2019, one of the worst locust plagues in decades has been devastating parts of East Africa and surrounding regions, consuming up to 1.8 million tonnes of vegetation a day.

Locusts are a group of short-horned grasshoppers. They are usually solitary, fairly bland-looking insects. Still, when conditions are right, they can switch into a 'gregarious' mode, becoming social, multicoloured eating machines that sweep across the landscape in swarms of up to 80 million locusts per square kilometre.

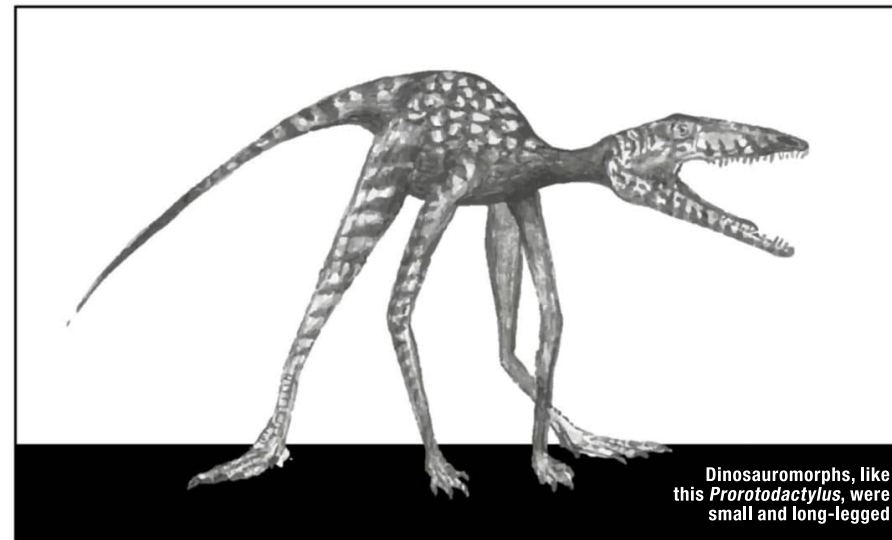
Swarming behaviour is triggered by high rainfall. When there's plenty of lush vegetation for the wingless nymphs (called

'hoppers') to feast on, their numbers swell, and the insects are no longer able to avoid each other. The sight, smell, and touch of other locusts cause a flood of serotonin in their brains, which in turn causes genes that control their gregarious phase to switch on, and 'solitary' genes to switch off. The result is a Jekyll-to-Hyde transformation. The gregarious nymphs form into large bands, before taking to the air once they reach their winged, adult stage. As they swarm, any solitary locusts they meet swiftly join the throng.

Why locusts evolved to swarm in the first place is still not fully understood, but a 2008 study suggested that it is because swarms close the gaps between separate patches of locusts, and this makes it harder for predators to move among them and pick the insects off. **RG**



ALAMY, GETTY IMAGES X2, FRANCO TEMPESTA/ABSOLUTE EXPERT: DINOSAURS/© 2018 NATIONAL GEOGRAPHIC PARTNERS LLC ILLUSTRATION DANIEL BRIGHT



Dinosauria, like this *Prorotodactylus*, were small and long-legged

ADAM KING, HUDDERSFIELD

## WHAT DID DINOSAURS EVOLVE FROM?

Dinosaurs are a type of reptile, and they evolved from another group of reptiles called dinosauria around 250 million years ago. The dinosauria were small and humble animals, and they didn't look anything like T. rex or Brontosaurus. Instead, they were the size of house cats, walked on all fours, and had long, skinny limbs like a greyhound. The dinosauria weren't at the top of the food chain, but their speed and agility ensured their success. **SB**



MAEVE BROWN, BRISTOL

## HOW CAN I PROTECT MYSELF FROM THE CORONAVIRUS WHEN SHOPPING?

The coronavirus SARS-CoV-2 is spread through respiratory droplets that leave our mouth and nose when we cough, sneeze, or sometimes even talk. These don't usually travel more than one metre, so by keeping two metres from other shoppers, you'll reduce the likelihood of being in the firing line. To make it easier to keep your distance, try to shop during off-peak hours, choose a store that's limiting the number of people who can be inside, and use self-checkout if you can. Keeping your hands clean is the other main thing you can do. If possible, wipe the trolley or basket handles with a disinfectant wipe when you arrive at the store. When you get home, wash your hands or use hand sanitiser before and after unpacking your bags. **JR**

## OLD WIVES' TALES

### EAT CURRY TO BRING ON LABOUR



Unfortunately for impatient mums-to-be, this one's a myth. It probably has its origins in the fact that curry often has other effects 'down there'. Spicy food is known to irritate the intestines (hence the post-curry diarrhoea that some people experience), and it might also irritate the uterus and in some cases cause small contractions. But there's no evidence that this could bring on labour. Castor oil – a vegetable oil from castor beans – is a more powerful laxative, and some small studies have concluded that the oil can help induce labour. In 2012, researchers in Germany suggested a possible mechanism, finding that acid in castor oil mimics the effects of hormone-like substances in the body called prostaglandins, which can stimulate contractions in the intestines and uterus. However, the evidence is mixed, and castor oil's laxative effects can cause nausea, diarrhoea and dehydration, so pregnant women are advised to avoid it.

There are a whole host of other foods and drinks that have been said to help bring on labour, including dates, pineapple, raspberry leaf tea, and aubergine (eggplant in the US). The latter is probably due to the labour-inducing claims made for a famous 'eggplant parmesan' dish at a restaurant near Atlanta, Georgia. But there are no scientifically proven ways to induce labour at home, so pregnant women are best off waiting it out. **AV**





CRAIG EDWARDS, WOLVERHAMPTON

WHERE DOES SOIL COME FROM?

Soil is a mixture of minerals, organic matter, living organisms, water and air. The minerals (about 50 per cent of soil) are particles of weathered rock, which include tiny grains of clay and silt as well as larger sand particles. The living organisms include fungi, bacteria and insects, and the organic matter incorporates dead plants and microbes, plus other animals in various stages of decomposition. The final product of decomposition is a dark, organic material called humus, which contains relatively high amounts of nitrogen – a nutrient that’s vital to plant health.

Initially, soils form from a ‘parent material’ on the Earth’s surface. This could be the bedrock that’s been eroded or material that’s been transported by glaciers, rivers or wind. Over time, more layers, or ‘horizons’, are built up. This process takes tens of thousands of years as rocks are slowly weathered, and organic matter accumulates. The properties of the soil depend on the local conditions. Sandy areas have gritty soils that drain rapidly; boggy areas have dark, spongy peat; clay-rich areas have sticky soils that crack when dry.

We usually take soil for granted, but it’s estimated that a quarter of all species live in or on soil, and we need it to grow 95 per cent of our food. Soil also plays a broader role in absorbing water (and thus reducing flooding) and locking away carbon. However, soil is under growing pressure from intensive farming and tilling, overharvesting, and the use of chemicals. As a result, we lose the equivalent of 30 football pitches of fertile soil every minute. **AFC**



## DEAR DOCTOR

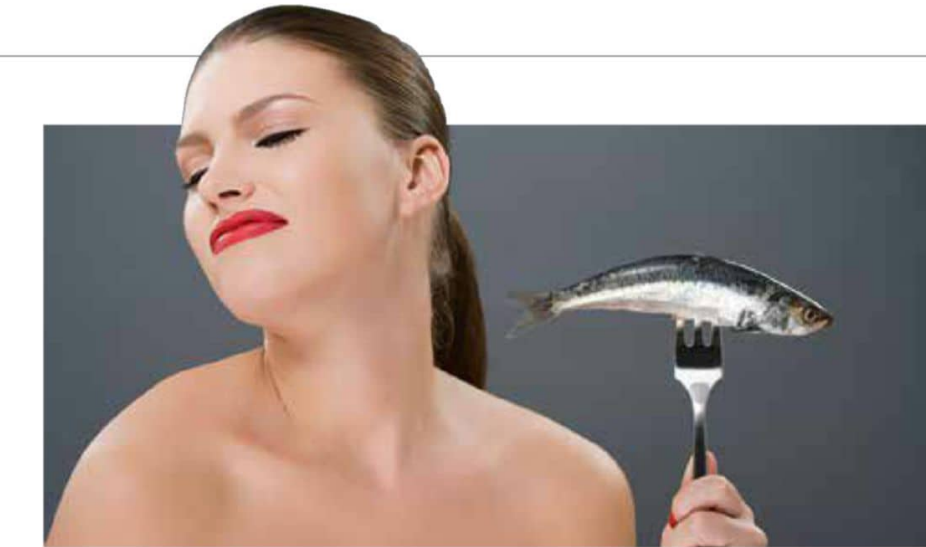
DELICATE ISSUES  
DEALT WITH BY  
SCIENCE FOCUS EXPERTS

### WHY DO I ALWAYS GET AN ENERGY CRASH IN THE AFTERNOON?

Your internal body clock, or ‘circadian rhythm’, can explain why you feel so sluggish after lunch. A tiny region controls the circadian rhythm at the base of the brain called the suprachiasmatic nucleus (SCN), which makes us feel sleepy in the evening by sending a signal to the body to release the snooze-inducing hormone melatonin, which also lowers our body temperature. However, we also experience a miniature version of this process between around 2 p.m. and 4 p.m. The reason for this isn’t apparent, but research suggests that some aspects of our circadian rhythm have a 12-hour cycle, as well as the primary 24-hour one.

The feeling of fatigue can also be intensified by other factors, such as eating a carb-heavy lunch, not getting enough sleep the previous night, or being dehydrated. If you’re really struggling, a post-lunch nap isn’t such a bad idea. Studies have shown that a 20- to 30-minute snooze can boost alertness, attention, and mood, and there are even companies who have invested in workplace sleep pods for their staff. That’s not feasible for everyone, though. Another option is to go for a lunchtime stroll. Light has a significant effect on our circadian rhythm, helping to calibrate the SCN, so a good dose of sunshine can be just as effective as a nap at setting you up for the afternoon. **SO**





BRENDAN FALVEY

IS IT POSSIBLE TO HAVE ZERO SENSE OF SMELL?

The medical term for this is ‘anosmia’. People can be born with no sense of smell, due to genetic factors, but most lose it later in life, sometimes permanently. Anosmia has many causes, including head injury, dementia, nasal polyps, and even snake bites. But the most common cause, accounting for up to 40 per cent of cases, is a

viral infection. Indeed, one reported symptom of the coronavirus disease COVID-19 is a loss of smell. It’s not yet known what causes this, but I experienced it for myself when I had a mild case of COVID-19 earlier this year. My sense of smell gradually returned, but even after three weeks, I still couldn’t smell coffee. **FM**

QUESTION OF THE MONTH

DILEEP BAGNALL, LANCASHIRE

WHAT ARE COWS COMMUNICATING WHEN THEY MOO?

Old MacDonald had a farm with an ‘oink oink’ here and a ‘moo moo’ there, but we’d be foolish to think that these vocalisations have no significance. Cows are smart, social animals. They have a rich repertoire of communication that includes moos, grunts, bellows and even non-verbal signals such as tail position.

In 2014, researchers at the University of Nottingham and Queen Mary University of London decided to delve a little deeper by recording ten months’ worth of moos and then using computer analysis to look for patterns. Just as our voices differ, the researchers found that each mother and calf have their individual calls that are believed to help them identify each other in a herd. The researchers could also

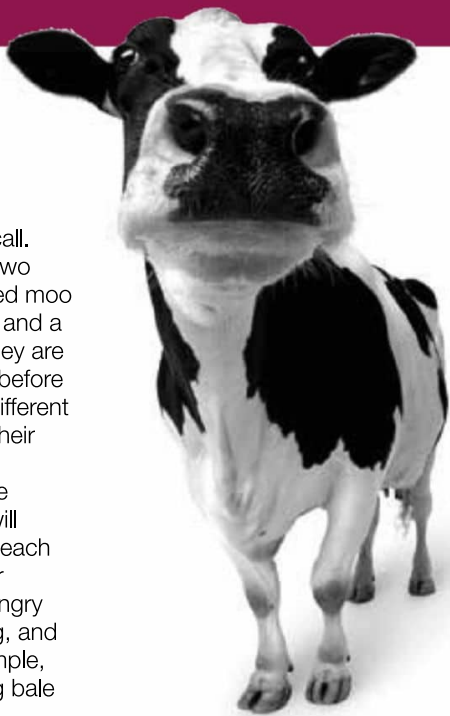
tell a calf’s age by the sound of its call. Meanwhile, mother cows produce two different maternal calls: a low-pitched moo when they are close to their calves, and a louder, higher-pitched moo when they are separated from their calves, or just before nursing. Calves, in return, make a different call when they are separated from their mother and/or want to suckle.

Of course, this is just the tip of the iceberg. Ask any farmer, and they will tell you that cows ‘talk’, not only to each other but also to those who care for them. Cows moo when they are hungry or stressed. They moo as a warning, and they moo in anticipation, if, for example, the farmer is approaching with a big bale of delicious hay. **HP**

NATALIE WEAVER (AGED 11)

WHY IS THE SKY BLUE?

It’s often thought it’s because of light reflected into the sky from the blue sea. In fact, it’s the result of sunlight being scattered when it strikes the air molecules in the atmosphere. Sunlight is made up of – literally – all the colours of the rainbow, and the complex physics of how light interacts with molecules means shorter-wavelength blue light is more strongly scattered than red light. As a result, it is blue-coloured light that ends up spread most widely across the sky, dominating its appearance. **RM**



GETTY IMAGES X4 ILLUSTRATION DANIEL BRIGHT

Email your questions to [questions@sciencefocus.com](mailto:questions@sciencefocus.com) or tweet us @sciencefocusQA



# THE EXPLAINER

## HOW DO I START STARGAZING AT HOME?

Being stuck at home could provide the perfect opportunity to get to know the night sky, and you don't even need a telescope. Here are nine tips from BBC Sky At Night magazine on stargazing with the naked eye



GETTY IMAGES X3, ALAMY X3



### DRESS FOR THE OCCASION

Before you even look at the sky, take a look at yourself in the mirror. Are you appropriately dressed? You're going to be outside for at least an hour or longer, and it can get cold even on summer nights. So dress appropriately, with a warm jacket, thick socks, and gloves, a scarf, and a hat. You'll want to look like one of the rosy-cheeked children playing happily in the winter snow from a vintage Ladybird book.



### PREPARE YOUR SITE

Find a spot in your garden where you can see as much of the night sky as possible, away from other houses, tall buildings, and trees. If you don't have a garden, you can also stargaze from a balcony or front step, or through a skylight. If you're going to be outside for a while, take a chair – a reclining chair will allow you to look upwards without straining your neck. Turn off all your outdoor lights and, if you can, get your neighbours to do the same. If you don't have somewhere to stargaze or if there's a lot of light pollution, then you might need to find another site (lockdown restrictions permitting!). Head to a dark spot in the countryside, or walk around the corner to your local park or playing field.



### ADJUST YOUR EYES

Once you're comfy, let your eyes adjust to the darkness. Astronomers call this process 'dark adaptation', and it takes about half an hour. Don't browse on your phone while you wait (its bright screen will ruin your night vision). If you need some light, use a red light torch, or a red bicycle light.



### SEE THE STARS

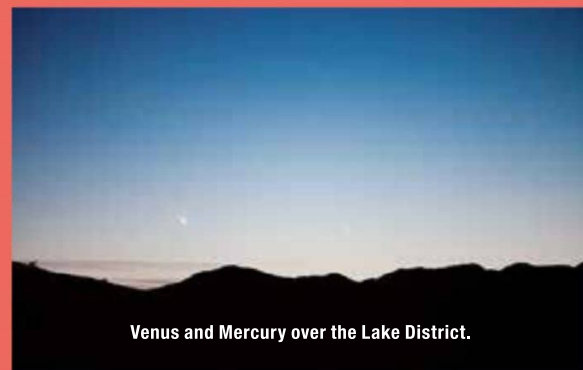
Once your eyes have adjusted, you won't believe how many more stars you can see. You might be able to notice subtle differences in the stars' colours, which depend on their temperature: the hottest stars are more of a bluish tinge, while cooler stars have a yellow, orange, or red tint.



→

## SPOT A METEOR

As you're gazing skywards, you might be lucky enough to see a meteor dash across the sky: a shooting star! These are tiny grains of space dust burning up in the atmosphere. Larger, brighter meteors, called fireballs, can survive their trip through the atmosphere and drop meteorites on the ground. Your best chance of seeing a shooting star is during a meteor shower when the Earth passes through the dusty trail left by a comet. One of the best annual showers is the Perseids, which peaks this year around 11-13 August.



Venus and Mercury over the Lake District.

←

## SPOT A PLANET

If you see a bright 'star' that isn't twinkling, it's almost certainly a planet. Why do stars twinkle, and planets don't? A star is so far away that its pinprick of light arrives in a narrow beam, which is easily distorted as it passes through our atmosphere (we see this as twinkling). Planets are closer, and their light (reflected from the Sun) comes to us in a thicker beam, which isn't so easily distorted. In June, there'll be a chance to see all five 'naked eye' planets (Mercury, Venus, Mars, Saturn, and Jupiter). For tips on how to spot them, visit [skyatnightmagazine.com/advice/skills/how-see-planets-night-sky-june](http://skyatnightmagazine.com/advice/skills/how-see-planets-night-sky-june).

## LOOK FOR PATTERNS

The stars can be joined up to form patterns. You might recognise one straight away: the saucepan-shaped Plough, which is visible all year round. The Plough is an 'asterism' – a star pattern that's not one of the official constellations. It forms part of the constellation Ursa Major (the Great Bear).

Very few of the 88 constellations look like the person, animal, or object they represent, so you'll need to use some imagination! If you return to your observing site in another season, you'll notice that the constellations you can see have changed. The Earth is in a different position in space as it orbits the Sun, and it's why it takes a year to properly get to know the sky, not just one night.



↗

## DOWNLOAD AN APP

Stargazing apps can be a great way to familiarise yourself with the positions of the stars and planets. You'll need to make sure you turn your screen brightness right down to keep your night vision, or turn on the app's red screen filter if it has one. Some good, free-to-download apps include Stellarium Mobile Free, SkyView Lite and Star Walk 2 Free.



## DISCOVER MORE

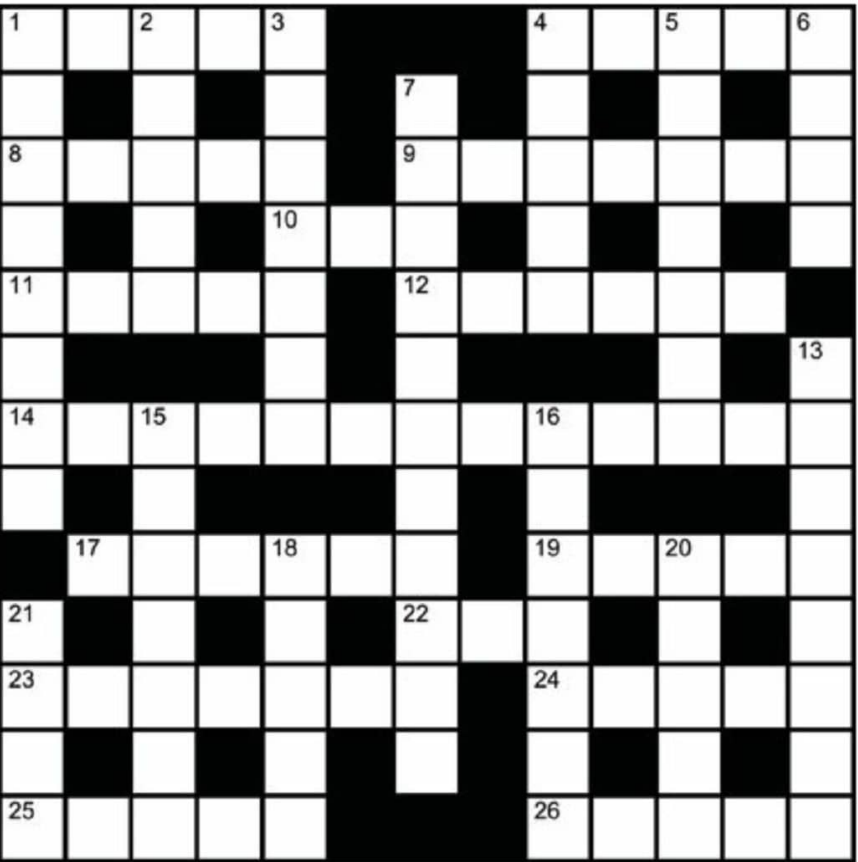
For more stargazing advice for beginners, head to [skyatnightmagazine.com/tag/astronomyforbeginners](http://skyatnightmagazine.com/tag/astronomyforbeginners)

←

## MARVEL AT THE MOON

Go outside on a cloudless night and reacquaint yourself with our closest celestial neighbour. Impact craters appear as bright patches on the Moon's surface, while the dark regions, known as lunar maria, are vast plains of solidified lava. The Moon's features cast more dramatic shadows and are hence easier to pick out when they're close to the 'terminator' – the dividing line between the Moon's dark and illuminated portions. A crescent or a gibbous moon can be just as interesting as a full moon, especially when seen through binoculars.





# CROSSWORD PUZZLE

GIVE YOUR BRAIN A WORKOUT

→  
**ACROSS**

- 1 Readily available where hot and cold can be found (2,3)
- 4 Doctor pursues firm oxygen pairing (5)
- 8 Train decathlete, initially by stream (5)
- 9 Almost commend a liberal officer (7)
- 10 Feel modest about growth (3)
- 11 Contributing element, removing first performer (5)
- 12 Regular figure is round, left unfinished (6)
- 14 Pop has it as a greenhouse gas (6,7)
- 17 Points to raise about losing a TV programme (6)
- 19 Sketch doctor at the back (5)
- 22 Heard first person getting an organ (3)
- 23 Greeting endlessly, ruined number (7)
- 24 Sap is from sycamores indeed (5)
- 25 Her and my form for a poem (5)
- 26 Surrender produce (5)

↓  
**DOWN**

- 1 Guns, alternatively, new in routine (8)
- 2 Colour includes a suggestion (5)
- 3 Friend confused Rome and another capital (7)
- 4 Some jewellery arrived on the second of November (5)
- 5 Macron upsetting Italy's top inventor (7)
- 6 Capital of Czechoslovakia (4)
- 7 Mere bandits wandering around wasteland (5,6)
- 13 Heading isn't fixed in deed (8)
- 15 Astronaut's return is naive, not starting attempt (2-5)
- 16 Methodically arranged for hospital worker (7)
- 18 Fireplace showing one front part removed (5)
- 20 I will be heard in the passage (5)
- 21 Less intelligent, first couple leaving jetty (4)

A SCIENTIST'S GUIDE TO LIFE

# HOW TO BAKE BREAD BRILLIANTLY

With life still in lockdown, more people than ever are turning to baking. Here's how to bake the perfect loaf, according to nutrition scientist **Haleh Moravej**



→ **TREAT BREAD-MAKING LIKE A SCIENCE EXPERIMENT**

Baking is a science, so don't guesstimate. For example, make sure that the water you add is at the right temperature. If it's too hot or too cold, the yeast won't work. Should the recipe says to add a certain amount of yeast or salt, ensure you do.

→ **STRONG FLOUR IS BEST**

Strong flour has the highest amount of protein. It contains glutenin and gliadin, which make gluten when water is added. If you use flour with low protein content, the bread is likely to be heavy and dense.

→ **KNEADING IS IMPORTANT**

When you stretch the dough, it helps to line up the messy strands of gluten. It's a bit like combing the tangles from your hair! It also makes the bread stronger.

→ **KNOW YOUR YEAST**

Yeast is a single-celled organism. Bakers use *Saccharomyces cerevisiae*, which means 'sugar-eating fungi'. As it eats sugar, it produces carbon dioxide, which helps make the bread light and bubbly. The process is fermentation. Connoisseurs of bread may prefer live yeast, but it only survives for a few weeks. Dry yeast has a longer shelf life because it's dehydrated. I

recommend another type of yeast called instant yeast, which is even more dehydrated. It rehydrates, gets to work on the bread quickly, and lasts longer, too.

→ **DON'T FORGET THE SALT**

Salt is hygroscopic, so it attracts water. When it's mixed into a dough that contains yeast, it absorbs moisture and helps control the fermentation.

→ **THERE IS CHEMISTRY BEHIND A CRUSTY TOP**

The much sought after 'brown crusty top' is caused by the Maillard reaction. It is a chemical reaction between amino acids and sugars that requires moisture and heat. One option is to spray the dough with water a few times while it is cooking. Another is to fill a baking tray with ice cubes and then place it in the bottom of your preheated oven before baking your bread to create steam.

→ **GO GLUTEN-FREE**

Gluten strands bind things together. Xanthan gum is a gluten-free binding alternative that can be added to many gluten-free flours, but I find that the bread it produces is too dense. Don't bother with special gluten-free flours. Go for naturally gluten-free grains like rice, chickpea, soy, and cornflour because they're straightforward to bake with.

→ **NEXT-LEVEL BREAD MAKING**

For something trickier, try sourdough. Sourdough bakers keep starter cultures of bacteria and yeast which they feed and manage. It's a bit like keeping a pet! **SA**

**NEED TO  
KNOW**

1

Don't guesstimate — baking is a science!

2

Proving cupboards are overrated. Simply cover your dough with a tea towel and prove at room temperature.

3

Use instant yeast — it has a long shelf life and works well.

**Haleh Moravej** (@HalehMoravej) is senior lecturer in nutritional sciences at Manchester Metropolitan University.





COMMENT

# HITTING THE WALL

Lockdown is tough, but there are ways we can alter our mindset and endure this challenging situation a little more successfully



ALEKS KROTOSKI

Aleks is a social psychologist, broadcaster, and journalist. She presents *The Digital Human*.

Lockdown is more of an endurance sport than a sprint, so unless you trained for it, there will be a moment when you hit the wall. I was on Week 2.5 when I started wailing like a little kid in front of my kid, lashing out at the doorframe, and being sent to my room by my husband. Not a good look for a grown-up. But emotions, stress, and uncertainty are tough things to tackle whatever your age, particularly when the race is already running and the finish line is a moving target.

Dr Nathan Smith is an expert in extreme stress. He spends his research time with people who live on the edge of physical, psychological, and social reality – like astronauts and polar explorers – people you and I are unlikely to encounter in daily life. But his work at the University of Manchester came in handy when I was at my low ebb during this crisis.

Quarantine is maddening because human beings like structure, Smith said to me over the phone when he graciously responded to my cry for help. We develop our lives to follow a certain routine. Some people – like me, it turns out – are more fixed than flexible. And when that's disrupted, we lose it. Combine that with a big dose of uncertainty and a feeling of powerlessness, and it's a recipe for self-sabotage.



Most people are terrible at noticing when things are going downhill, Smith explained, but the first signs that there might be a problem is that we stop paying as much attention to ourselves and our belongings as we might otherwise. Out in the field, holes might start appearing in a tent or a sleeping bag. At home, rubbish might start piling up, or we might stop showering. If there's anyone

cat. We are still in charge of our thoughts, even if our actions have been locked down. And we can wrestle autonomy back into our lives by setting up a routine that helps us structure our days and give us a sense that we are still in charge of our lives.

Polar explorer Eric Larsen told me that around Day 40 of any big expedition he's been on, he has a moment of release when he lets go of the old 'normal' and gives in to the new. It's the redemption song to the temper tantrums on the ice, and the routines that

around us, they might start hearing more negative things coming out of our mouths. It might seem that we've lost optimism and hope. There might be more fights. More tears. More unhelpful vices.

While we might not be able to control the outside world, we can control our mindset. We can choose how we think about things – acknowledge that there is more than one way to skin a

help him get through each day but ultimately make his journey monotonous and incredibly arduous. We may not have the same physical demands as Eric, but we can certainly learn from people like him who put themselves in extreme situations. And after this race, I'll be trained up for the next round of whatever the Universe has in store for us. **SA**

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